EXPERIMENTAL STUDY ON THE PARTIAL REPLACEMENT OF FINE AGGREGATES WITH PLASTIC IN THE PRODUCTION OF CONCRETES.

BY

BELLO, Clinton Aisosa

ENG1905242

A PROJECT SUBMITTED IN

PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.ENG).

IN

THE DEPARTMENT OF CIVIL ENGINEERING,

FACULTY OF ENGINEERING,

UNIVERSITY OF BENIN, BENIN CITY, NIGERIA

APRIL, 2024.

CERTIFICATION

This is to certify that this work was carried out by, BELLO, Clinton Aisosa with Matriculation number (ENG1905242), 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. UCHENNA UKEME

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

HEAD OF DEPARTMENT

Name: ENGR. DR. MRS NGOZI IHIMIKPEN

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

DEDICATION

This project is dedicated to God Almighty and to my beautiful parents who has put tireless effort towards making my academic path successful and to my lecturers and professors for sharing their knowledge with me.

ACKNOWLEDGEMENT

My deepest thanks are offered 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 honor goes to Him alone.

My profound gratitude is offered to my project manager, Engr. Uchenna Ukeme, for his continuous leadership and inspiration throughout this project, as well as for his relentless efforts in spite of his hectic schedule.

I convey my sincere gratitude to Dr. Ngozi Ihimekpen, the Head of the prestigious Department of Civil Engineering, for her significant effect 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. Dr. S.D. Iyeke, Engr. Dr. E. Nwankwo, Engr. Dr. S.E. Okonofua, Engr. Dr. N. Kayode-Ojo, Engr. Dr. A. Rawlings, Engr. Ehi Oria-Usifo, Engr. O. Osasu, Engr. Dr. R. Ilaboya, Dr. L.O Bobor, Engr. B. Omosefe, 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.

A special gratitude goes out to all of my friends and classmates who supported me during this education. I pray that God will likewise be there for you when you need him

Finally, my thanks goes to my family and friends for all the love and support. May God continue to bless you all.

ABSTRACT

The project titled "Experimental Study on the Partial Replacement of Fine Aggregates with Plastic in the Production of Concretes," was carried out with the aim of knowing the effect of partially replacing fine aggregates with plastic waste in concrete production. The aim is twofold: to mitigate environmental impact by repurposing plastic waste and to evaluate the performance of plastic-aggregate concrete.

Methodologically, various types of plastic waste are selected and processed to suitable sizes for incorporation into concrete mixes. Comprehensive testing is conducted to assess both the fresh and hardened properties of the resulting concrete specimens. Tests include workability assessments using slump tests, as well as mechanical property evaluations such as compressive tests. The spent plastics were gathered, ground into smaller components, pulverized in order to get granules of plastic lower than 4.75mm size. Sieve studies were carried out for particle size distribution. 9 nos. of 10cm x10cm x10 cm cement concrete Cubes of 1:1.5:3 (C25) mix were cast for 0%, 5%, 10%, 15%, sand being substituted by Pulverized plastic material. Volumetric proportioning was utilized instead of design mix since the density of plastic material was too low. Workability test, weight and compressive strength of the cubes were determined.

The results of the study shows that the slump of the fresh concrete decreased with increase in the replacement of the fine aggregate. This implies that the presence of plastic in the concrete decreased its workability. Also, the control sample, with no replacement, exhibited the highest compressive strength throughout the curing periods of 7, 14, and 28 days. As the percentage of sand replacement increased, there was a noticeable decrease in compressive strength. Notably, the replacement of 5% of sand with plastic material showed a gradual decrease, while beyond 10%, the decrease became more significant. This trend is attributed to the inability of plastic waste aggregate to effectively interact with the cement paste, unlike natural aggregate.

Recycling of plastic trash with river sand decreases its negative environmental impact of river sand quarries, reduces the depletion of natural resources Based on the findings of this study, it can be concluded that the replacement of natural sand with plastic waste aggregate in concrete production leads to a reduction in compressive strength. However, the similarity in particle distribution between natural sand and plastic material suggests the potential for utilizing plastic waste as a partial replacement for sand without significant compromise in textural properties.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The Solid waste disposal is a worldwide problem. Large amounts of various of waste materials are being generated by industrial, agricultural, mining and home operations. Solid waste materials are present in the world to pollute the environment like Fly ash, marble sludge waste, incineration ash, rice husk-bark ash, bagasse ash, bottom ash, plastic waste, stone wastes, ceramic waste, copper slag, agricultural wastes, copper tailings, carbon steel slag, coal waste, mine waste, construction and demolition waste, ceramic waste, foundry slag, limestone waste, wood ash, furnace slag, welding slag, phosphor gypsum slag, imperial smelting furnace (ISF) slag, etc., are some of the example of solid waste material that pollutes the environment People living standards are growing the large rise of plastic garbage. As a result of this, disposal of waste plastic has also become a huge environmental issue in all regions of the world. It was projected that 1.5 billion plastic are created in the world each annum (Rafat and Tarun, 2004; Weiguo Shen et al., 2013). Every year millions of plastic are dumped or buried all over the world, constituting a very serious threat to the biosphere. It is estimated that every year over 100 million plastic complete their service life and out of that, more than 50% are tossed to landfills or waste, without any treatment. By the year 2030, the population would reach 120 million yearly. Including the hoarded plastic, There would be 500 million plastic to be thrown on a regular basis (Azevedo F et al., 2012). In India alone, the total number of discarded plastic would be an estimated 112 million per year after retreading twice (Mukul Chandra Bora , 2010). The plastic wastes which are disposed to landfills constitute one key portion of solid waste. The polymers are heavy, yet 75% of their volume is vacant and these voids give possible places for the breeding of rodents. There is a propensity for the plastic to rise in a land-fill and float to the surface (Neil N. Eldin, Ahmed B. Senouci, 1994;) Stock piled plastic also present a variety of health, environmental and economic problems through air, water and soil pollution (Bhavna Tripathi., 2012). The plastic hold water for a longer duration due of its specific shape and impermeable nature giving a breeding home for mosquitoes and numerous pests. Use of waste plastic as a fuel has been forbidden owing to environmental considerations (Gregory Marvin Garrick 2001) Plastic burning, which is the quickest and cheapest way of disposal, causes major fire hazards and air pollution. (Bhavna Tripathi., 2012). It increase the environment temperature in that area rises and the noxious smoke with uncontrolled releases of potentially harmful substances is particularly dangerous to humans, animals and plants. Once ignited, it is exceedingly difficult to extinguish as the 75% empty area may hold a lot of free oxygen. It was claimed that a severe fire threat occured in Wales in an area where 10 million plastic were discarded. The plastic have been burning constantly for at least 15 years generating major health and environmental hazards (Gregory Marvin Garrick, 2001). In addition, the residual powder left after burning pollutes the soil. The oil that is created by the melting of plastic can potentially damage soil and water (Neil N. Eldin, Ahmed B. Senouci, 1994).

Therefore, the replacement of conventional aggregate in concrete mixtures with waste plastics has considerable environmental potential. This basic notion could lead to an effective waste management solution for plastics and effectively boost the sustainable acquisition of aggregates for concrete, achieving material reuse targets

1.2 STATEMENT OF THE PROBLEM

Wherever it is possible, cheaper alternative to the various replacement of fine aggregates in various concrete materials are being sought after due to the exponential rise in the price of cement as a building material in today's society. Tho most expensive of these fine aggregates is cement. It is possible to overstate the value of fine aggregates in concrete.

Modern plastics have both physical and mechanical properties that are desirable in engineering. da Costa et al., 2016, state some of their desirable characteristics as being low cost, resistant to water, chemical, temperature and long-term natural light and UV- allowing plastics to be versatile in a range of industries. The goal of this investigation is to offer suggestions that can effectively close this gap of sand as a fine aggregate for concrete production

1.3 AIM AND OBJECTIVE OF THE STUDY

The aim of this study is to investigate the feasibility and effectiveness of partially replacing fine aggregates with plastic waste in the production of concrete.

The objectives are as follows:

1. To assess the influence of incorporating plastic waste on the fresh properties of concrete, including workability.
2. To evaluate the impact of plastic waste on the mechanical properties of hardened concrete, particularly compressive strength.
3. To analyze the environmental implications of utilizing plastic waste in concrete production, including its potential to reduce the consumption of natural resources and mitigate environmental pollution.
4. To provide insights into the practical applications and limitations of plastic-aggregate concrete in construction projects.

1.4 SCOPE OF STUDY

The scope of this study encompasses the investigation of partially replacing fine aggregates with plastic waste in the production of concrete. Specifically, the study focuses on the following aspects:

The study shall include

1. The study considers various types of plastic waste, including polyethylene terephthalate (PET), high-density polyethylene (HDPE), and polypropylene (PP), among others, for potential incorporation into concrete mixes.
2. Different percentage replacements are explored to determine the optimal percentage of plastic replacement for fine aggregates while maintaining the desired concrete properties.
3. Comprehensive testing is conducted on both fresh and hardened concrete specimens. Tests include assessment of slump and compressive strength.
4. The study evaluates the environmental implications of using plastic waste in concrete production, considering factors such as resource conservation, energy consumption, and reduction of plastic pollution.
5. The study acknowledges potential limitations, including constraints related to material availability, compatibility of plastic with cementitious materials, and the need for further research to address technical challenges and optimize performance.
6. Insights gained from the study contribute to understanding the practical applications of plastic-aggregate concrete in construction projects, including its suitability for various structural and non-structural applications.

1.5 JUSTIFICATION OF STUDY

The endeavor to explore the feasibility of integrating plastic waste into concrete production stems from a profound concern over the environmental repercussions of conventional construction practices. With traditional concrete heavily reliant on finite natural resources like sand and gravel, the industry faces a pressing need for sustainable alternatives. By repurposing plastic waste as a partial replacement for fine aggregates, this study endeavors to mitigate environmental degradation and alleviate the strain on natural ecosystems. Moreover, in the face of the escalating plastic pollution crisis, this research assumes a crucial role in offering a tangible solution to manage plastic waste while curbing its detrimental impact on ecosystems and human health.

Beyond its environmental imperatives, the integration of plastic waste into concrete holds promise for fostering sustainable construction practices with far-reaching social and economic implications. Not only does it present an opportunity to reduce reliance on virgin materials and divert plastic from landfills and oceans, but it also stands to bolster the development of recycling infrastructure and the circular economy. Through the creation of demand for recycled plastic materials, this study aims to engender socio-economic benefits, ranging from job creation in the recycling sector to cost savings in construction projects. Furthermore, by advancing scientific understanding and disseminating research outcomes, this endeavor seeks to catalyze innovation in sustainable construction materials and practices, thus paving the way for a more environmentally conscious and socially responsible built environment.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The literature review serves as a foundational element in understanding the context and significance of integrating plastic waste into concrete production. This chapter delves into the existing body of knowledge surrounding traditional concrete composition, the environmental impact of concrete production, previous studies on the utilization of plastic as a substitute for fine aggregates, and the properties of plastic-aggregate concrete. By synthesizing insights from previous research, this review sets the stage for the current study's exploration of the feasibility and implications of incorporating plastic waste into concrete mixes.

The utilization of plastic waste as a partial replacement for fine aggregates in concrete production has garnered significant attention in recent years due to its potential to address both environmental and economic challenges. In most regions of the world, concrete is the material used in civil engineering projects that is most frequently. It is a building material that is primarily composed of Portland cement or another hydraulic cement, fine aggregate (sand), and coarse aggregate (granite), mixed with water and (or) without admixtures. Over time, it cures and becomes stronger. Following water, it is one of the most used commodities worldwide (Graw,2014). Concrete need not be brought up while discussing modern industry progress. These components are typically blended in a certain proportion to achieve the goal strength of the concrete. The cement and water combine exothermically to create a paste that binds the aggregate particles together by releasing heat into the surrounding environment. The mixture solidifies into a rock- like solid mass that has high compressive strength but low-tension resistance. Because of this, the mass of concrete is often strong in compression but weak in tension (Ramez anianpour, 2020). Among the most resilient building materials is concrete. This is because studies have shown that it offers higher fire resistance when compared to wood and other porous materials, which are also utilized in construction activities, and it accumulates a sizable amount of strength over time. The service or design life of concrete structures is typically very lengthy (Chung, 2012). Because concrete structures can resist rust better than steel and other ferrous materials, they are also frequently utilized in oil industry installations (Bruno, 2016). In the building sector, it is the artificial material that is most frequently used. This has been attributed to its wide range of uses (Greg, 2017).

Previous research by Siddique and Naik (2011) demonstrated that incorporating plastic waste in concrete can lead to improvements in certain mechanical properties while also reducing the consumption of natural resources.

Similarly, studies by Tittarelli et al. (2018) and Sarker et al. (2020) explored various types of plastic waste, such as polyethylene terephthalate (PET) and high-density polyethylene (HDPE), and their effects on the fresh and hardened properties of concrete. These investigations revealed promising results, indicating that plastic-aggregate concrete can meet the performance requirements for a wide range of construction applications.

Furthermore, the environmental implications of using plastic waste in concrete production have been a focal point of scholarly inquiry. Research by Silva et al. (2019) emphasized the potential for reducing carbon emissions and energy consumption through the incorporation of plastic waste, thereby contributing to the sustainability of concrete manufacturing processes. Additionally, studies by Gómez-Soberón (2017) and Kou et al. (2020) highlighted the role of plastic waste in mitigating the environmental impact of both concrete production and plastic pollution, underscoring the importance of exploring innovative approaches to waste management and resource conservation in the construction industry. Building upon these insights, the current study aims to contribute to the growing body of knowledge on plastic-aggregate concrete by conducting empirical research to assess its technical feasibility, environmental benefits, and practical applications in construction.

2.1 CONCRETE

2.1.1 Compositions of concrete

Concrete is mainly composed of cement, aggregates (fine and coarse), binder (cement), and admixtures if necessary (jerzy wawrzenczyk, 2006). A typical concrete material according to its constituents is shown on fig 2.1.

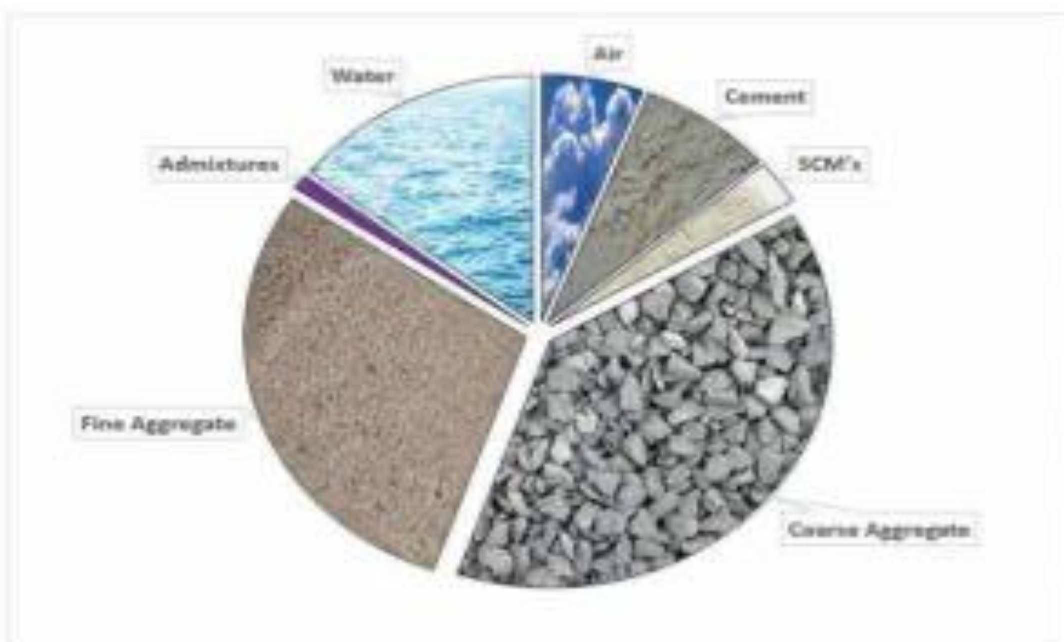

Figure 2.1 showing the composition of concrete by volume.

2.1.2 CEMENT

Cement is a powdery substance that serves as a binding agent in construction materials, particularly in the production of concrete and mortar (Ramez Amanpour, 2020). It plays a crucial role in holding together the various components of these materials and providing strength and durability. Composition of Ordinary Portland Cement (OPC):

i. Ordinary Portland Cement (OPC) is the most commonly used type of cement. Its composition typically includes the following major constituents:

ii. Limestone (Calcium carbonate - $CaCO_3$): This is the primary source of calcium in cement production. The limestone is usually obtained from quarries and mines.

iii. Clay or Shale (Silica, Alumina): These materials provide silica (SiO_2) and alumina (Al_2O_3), contributing to the formation of the silicate and aluminosilicate phases in cement.

iv. Silica (Silicon dioxide - SiO_2): Additional silica may be added to the mixture to adjust the properties of the cement.

v. Alumina (Aluminum oxide - Al_2O_3): Alumina contributes to the formation of certain phases in cement that influence its properties.

vi. Iron Ore: Iron ore is added to provide iron oxide (Fe_2O_3), which imparts color to the cement and influences its strength.

vii. Gypsum (Calcium sulfate dihydrate - $CaSO_4 \cdot 2H_2O$): Gypsum is added to regulate the setting time of the cement. It controls the rate of hydration and prevents flash setting.

viii. The raw materials go through a process called clinkerization in a kiln, where they are heated to high temperatures, resulting in the formation of clinker. The clinker is then ground into a fine powder, which is the cement that is used in construction.

ix. It's important to note that there are various types of cement, each with its specific composition to meet different construction requirements. Additionally, there are blended cements that combine Ordinary Portland Cement with supplementary cementitious materials like fly ash or slag for enhanced performance and

2.1.2.1 Physical Composition of Cement

Cement, particularly Ordinary Portland Cement (OPC), possesses several physical properties that are important for its performance in construction materials. Here are some key physical properties of cement:

A. Fineness

i. Cement is usually ground into a fine powder to enhance its reactivity and improve the strength of the resulting concrete.

ii. The fineness of cement is measured by the surface area it occupies per unit mass.

B. Particle Size Distribution:

i. The particle size distribution of cement particles affects the hydration process and the workability of concrete.

ii. A well-graded distribution ensures better packing and improves the strength and durability of the concrete.

C. Setting Time:

i. Setting time refers to the time taken by the cement paste to change from a plastic state to a solid state.

ii. Consists of initial setting time and final setting time which are crucial for construction work and the handling of concrete.

C. Soundness:

i. Soundness is the ability of cement to retain its volume after setting without undergoing excessive expansion or contraction.

ii. This property is crucial to prevent the development of cracks in the concrete.

D. Specific Gravity:

i. Specific gravity is the ratio of the density of cement to the density of water.

ii. It helps in estimating the void content in cement, which can affect the volume of concrete produced.

E. Bulk Density:

i. Bulk density refers to the mass of cement per unit volume.

ii. It influences the quantity of cement required in a given volume of concrete and is essential for mix design.

F. Colour:

i. Cement is typically gray in color, but variations may occur depending on the raw materials and the manufacturing process.

ii. The color of cement can impact the aesthetic appearance of concrete.

Physical Properties	***Test results***	***Limits of (I.O.S.) No.5/1984***
Specific surface area (Blaine method), m^2/kg	483	≥230
Setting time (Vicate apparatus), Initial setting, h:min Final setting, h:min	 2:50 4:30	 ≥00:45 ≤10:00
Compressive strength, MPa 3 days 7 days	 35.60 40.70	 ≥15.00 ≥23.00
Soundness (Autoclave) method, %	0.25	≤0.8

Figure 2.2 physical properties of cement (Chung, 2012).

Table 2.1 Chemical composition of cement (Dangote, 2014)

Property	**Values**
Lime	60.87
Alumina	5.36
Soluble silica	20.55
Iron oxide	4.00
Chloride	0.0173
Magnesia	0.74
Sulfuric Anhydride	1.83
Insoluble residue	2.93
Al_2O_3/Fe_2O_3	1.34

2.1.3 Aggregates

Aggregates used in the production of concrete generally fall into two categories. They are the aggregates, both fine and coarse.

2.1.3.1 Fine Aggregate

Any aggregate that can pass through a 5 mm sieve is referred to as fine aggregate. In contrast to coarse aggregate, it has a fine texture and smaller physical particles. Natural sand, powdered stones, or stone dust are all included (Musa, 2017).

2.1.3.2 Coarse Aggregate

Usually referred to as granite and is any aggregate that mostly contains particles that are retained on a 5 mm sieve. Crushed stone and crushed or uncrushed gravel are included. It is larger than the fine aggregate and has a rougher physical texture (Zainab, 2011). Granite or broken rocks are used to make coarse aggregate. Rocks holding more over 20% (by volume) of dark, or ferromagnesian, are nearly never called granite, as are rocks containing less than 20% (by volume) of quartz.

2.1.4 WATER

Concrete should only be made with water that complies with Section 5.4 of BS:456 - 2000. "Water used for mixing and curing must be devoid of harmful quantities of oils, acids, alkalis, salts, sugar, organic compounds, or other substances that may be eroding concrete and steel since it is anticipated to be drinkable and fit for drinking. The usual belief is that if the water is fit for drinking, it will also be fit for building concrete (Somayaji, 2015). In order to create concrete, water is a necessary ingredient. Water's moisture contributes to concrete's strength throughout the curing process. Exothermic hydration, a chemical interaction between cement and water, causes concrete to set. The heat of hydration of the concrete is a measure of the heat typically produced by this reaction (Mehta, 2013). To fully complete the hydration reactions, 0.35 percent of water must be added to any weight of cement used to make concrete (Somayaji, 2011).

2.2 Workability of Concrete

The capacity to be carried, poured, compacted, and finished with ease and homogeneity to prevent bleeding or segregation throughout the forming and curing process is known as workability in newly mixed and cast concrete or mortar (Hassan, 2016). Concrete's workability is negatively correlated with its strength (Gosh, 2017).

Three standard tests are used to assess the workability of fresh concrete paste. Those are

i. Slump test

ii. Vee-bee test

iii. Compaction Factor test. (Gosh, 2017)

2.3 Grading of Concrete Normal concrete

The compressive strength of concrete, which is typically evaluated on the 28th day following casting, is referred to as concrete grade or strength class. It speaks of the concrete's crushing strength on the 28th day after it was cast as cubes or cylinders (Adebayo, et al., 2018).

The grade of concrete is indicated by adding the letter M to the specified MPa strength. For instance, concrete grade M30, where M stands for mix, was designated as having a 30MPa compressive strength. Based on the demands of the structural design, the concrete construction grade is chosen (Anon, 2011).

Table 2.2 The different grades of concrete, mix ratio and their compressive strength

Classification of Grades of Concrete			
Designation	Mix Proportion (Cement: Sand: Coarse aggregate)	Characteristic Compressive strength in N/mm^2	Group
M5	1 ; 5 ; 10	5	Lean concrete
M7.5	1 ; 4 ; 8	7.5	
M10	1 ; 3 ; 6	10	Ordinary concrete
M15	1; 2 ; 4	15	
M20	1; 1.5 ; 3	20	
M25	1; 1 ; 2	25	Standard concret
M30	Design mix	30	
M40		40	
M50		50	
M55		55	
M60		60	High strength concrete
M80		80	

2.4 Concrete Mix Ratio (CMR)

This refers to the proportion in which the components of concrete are combined to produce a concrete with a specific strength for a specific construction purpose. The ratio of cement to fine aggregate (sand) to coarse aggregate is used to describe it (gravel). The strength requirements of the structure and the mix design of the materials to be used determine the mix ratio to be utilized in creating a specific concrete (Bhushan,2019). Typical mix ratios are 1:2:4, 1:1.5:3, 1:1:2, and 1:3:6. (Bhushan,2019). However, the 1:2:4 mix ratio, which produces grade 20 concrete, is the most common. on the other hand, "concrete mix design" refers to a technique for estimating the right quantity of concrete components and determining the necessary ratios in order to produce concrete with the requisite minimum strength and reasonable durability at a reasonable price (Bhushan, 2021).

On the basis of common laboratory and field experiments, concrete design regulations typically specify the normal and standard concrete mix ratios for different construction projects.

Concrete mix design is crucial because it gives the building engineer the knowledge, they need to reduce the number of materials used while still preserving the stability and safety of the structure.

2.5 Properties of Concrete

Concrete has several inherent traits that can be used to judge whether it has desired characteristics. The majority of these characteristics change with time as concrete ages because of its sluggish curing process. The strength of normal concrete usually varies between 20 MPa to 40MPa. Concretes that have about 50MPa strength are commonly referred to as High Performance Concrete (HPC).

2.5.1 Concrete Durability

As a result of ice, atmospheric pollution, rain, or any other dangerous environmental conditions, concrete has been found to have a strong resistance to physic-chemical attack from its surroundings (Bade, 2012). Since it can withstand these circumstances or attacks with little to no flaw, concrete is typically a very good choice for structures located in practically every area (Usman, 2017).

2.5.2 Porosity and Density of Concrete

Typically, these characteristics are what give concrete its strength and longevity. Concrete performs better and is more durable when it has fewer pores, while the opposite is also true

(Mohammad, 2010). Simply improving the size and packaging of the aggregates while the water content is being decreased can increase the density of concrete.

2.6 Plastics

Plastic is an incredibly versatile category of materials that are used in packaging, construction, medical equipment, and electronics. This synthetic or semi-synthetic material is derived from either petrochemicals or natural substances such as cellulose or starch and can be molded using various techniques. However, with the increasing production and disposal of plastic, there is a growing concern about its impact on the environment and human health.

Plastic was first discovered in 1839 when Charles Goodyear stumbled upon a method called vulcanization, which made rubber more resilient and elastic. Charles Goodyear's invention was also one of the first polymer mixtures to be created. In 1855, Alexander Parkes discovered celluloid, otherwise known as Parkesine. This material is a combination of camphor/lime and cellulose nitrate. It was also the first thermoplastic that became flexible when heated and stiff when cooled. There have been several significant discoveries in the succeeding years, including: the isolation of PVC in 1835 by French physicist Victor Regnault; John Wesley Hyatt’s creation of the first synthetic polymer (or industrial plastic) in 1869; and the introduction of transparent food packaging in 1900 by Edward Brandenberger.

2.6.1 Physical properties of plastic

It's not too heavy

i. it's application is adaptable

ii. Usually lightweight with a high strength-to-weight ratio.

iii. Very versatile.

iv. Moldable into different shapes and sizes.

v. Thermally and electrically insulating.

vi. Inexpensive.

vii. Resistant to chemicals.

viii. Very durable.

ix. Non-biodegradable.

x. Usually clear and can be colored in different hues.

xi. Different textures

2.6.2 **What Is Plastic Made Of?**

Many polymers, both manmade and natural, are utilized to manufacture plastics. Coal, natural gas, cellulose, starch, crude oil, and salt are a few of the most prevalent ingredients in the creation of plastic. The polymerization and poly condensation processes, which both require particular catalysts, are the principal ways for making plastics. In a polymerization reaction, monomers such as propylene and ethylene are combined to produce lengthy polymer chains. Each polymer has a specific size, structure, and set of properties that depend on the individual basic monomers involved.

Venkatesh (2017) researched mechanical characteristics of concrete with addition of plastics in concrete. Modifier was applied in percentage like 3%, 5%, 10%, 15% so as to exchange a equivalent amount of cement and fine aggregates. Tests were undertaken on coarse aggregates, fine aggregates, cement and modifiers (waste plastics) to find out their physical qualities. These tests were conducted at temperature and these tests include slump, fresh density, dry density, compressive strength. Cubes were casted and tested for 7- & 28-day's strength. By analyzing the test results, the compressive strength of plastic concrete has slightly decreased in comparison to regular concrete

Zainab Z. Ismail et al. (2007) observed that thirty kilograms of waste plastic of fabi form was employed as a partial substitute for sand by 0 %, 10 %, 15 % & 20 % with 800 kgs of concrete mixtures tested at temperature. These tests involve performing slump, fresh density, dry density, compressive strength, flexural strength, and toughness indices. The results confirmed the arrest of the spread of micro cracks by inserting waste plastic of Fabi form shapes to concrete mixtures. The compressive strength values of all waste plastic concrete combinations tend to decline below the values for the reference concrete mixtures with increasing the waste plastic ratio in the least curing ages. This may be related to the decrease inside the adhesive strength involving the surface of the waste plastic and cement paste, moreover waste plastic is hydrophobic material which can restrict the hydration of cement.

Sulaiman Mustafa Khazaal et al. (2020) studied the effectiveness of employing two types of waste plastic Poly vinyl chloride (PVC) as sand aggregate substitute in concrete mixtures. Various concrete specimens constructed and submitted to compressive testing to examine the effect of adding the two types of recycled plastic materials as fine aggregate replacement on the strength development of the mixes. Five mixes for each type of waste plastic were created with varied replacement percentages (and (10%, 15%, 30%, 45% and 60 %) and compared. The comparison indicated a considerable increase in the compressive strength after 28 days when using PVC at 15% and 30%. The 15% replacement level exhibited 8.3% rise in compressive strength whereas 30% replacement level showed 3% gain in compressive strength. However, all the substitution percentages for PP exhibited considerable losses in compressive strength.

Adewumi John Babafemi et al. (2018) presented a detailed review on the engineering features of waste recycled plastic. Workability increases as the content of coarse recycled waste plastic aggregate increases, up to 50%. Beyond this level, workability decreases. The workability of concrete could rise or decrease as the amount of fine recycled waste plastic aggregate increases dependent on the shape and size of the particle, water content. Plastic aggregate leads to a large increase in air content of concrete because to the uneven shape, immiscibility of plastic and natural sand, and hydrophobic characteristic of plastic. A progressive drop within the compressive strength development occurs with a rise within the content of plastic aggregate (both fine and coarse). Some tests, however, revealed a gain in compressive strength for modest volumes of regenerated waste plastic. When plastic aggregate fiber is applied, a discount in compressive strength with increase in fiber content and length is documented due to the increase in air content. The elastic modulus drops linearly as the quantity of plastic aggregate increases. However, the decline in the elastic modulus is lower than the drop in compressive strength. A decrease in the flexural/splitting lastingness of plastic aggregate concrete is reported. The substitution of natural aggregate with plastic aggregate (less than 20% waste plastic fiber), an increase in the flexural/tensile characteristics can be achieved. The ductility of concrete is greatly increased with the use of plastic aggregate, up to 50%. However, the fracture energy falls with the increasing in plastic aggregate concentration. Like mechanical strength, the inclusion of waste plastic also contributes to the increased shrinkage, water absorption, and reduced thermal conductivity of concrete.

Lavang Kumar Agarwal et al. (2019) studied almost 30 specimens of concrete were prepared, the concrete compressive strength and its behavior was investigated along a time span of seven days and 28 days with 6%, 10%, 12% & 15% replacement of coarse aggregates with High Density PVC waste plastic aggregates and also a kind of Portland pozzolanic cement with 30% fly ash. Result reveals that the compressive strength of concrete for M 25 grade at 7 days with 6% replacements shows nearer equal strength and for 28 days shows a increase or nearer equal strength compared with normal or basic values of M 25 grade concrete. Whereas, with 10% replacements indicates a modest decline in strength both at 7 & 28 days. With 12% replacements shows an excellent decline in strength both at 7 & 28 days, but, with 15% replacements shows, strength virtually reaches to 0N/mm. Thus, 6% replacement concrete could also be utilized in tiny concrete structural components and should be utilized in nonstructural members. These 10% replacement concretes could also be applied in nonstructural elements. 12% & 15% replacement concretes can't be even utilized in non-structural elements.

Abduel Majid et al. (2013) exploited rigid polyvinyl chloride waste (PVC) as partial replacement of natural coarse aggregate in concrete material. The percentage of PVC waste in the concrete mixture ranged from 0% to 25% based on volume of the natural aggregate. The influence of the % of PVC on slump, weight, dry density, compressive force of the concrete was examined. The results demonstrated that the addition of PVC waste to the concrete mixture led to decrease the compressive force of the generated concrete. The reduction in the value of compressive force did not exceed 4.40%, 12.10%, and 17.57% when the proportion of PVC was increased to 5%, 10% and 20%, respectively. The influence of water quantity in the combination was also tested for the samples containing 5% PVC. The findings indicated that the quantity of water had a substantial effect on the mechanical properties and the optimal quantity of water for maximum concrete performance was determined to be 215 kg/m under the experimental conditions. In addition, the integration of the PVC waste in the concrete may lower the plastic waste disposal cost and consequences. The density of the PVC waste was fixed to be 1.36 g/cm3.

CHAPTER THREE

METHODOLOGY

This chapter outlines the methodology employed in conducting the experimental study on the partial replacement of fine aggregates with plastic in the production of concretes. It details the selection of materials, mix design procedures, sample preparation techniques, testing protocols, and data analysis methods used to investigate the properties of plastic-aggregate concrete. The methodology section provides a systematic framework for conducting the study and ensures the reproducibility and reliability of the results obtained.

For the completion of the aim and objectives of this project the following strategies were employed.

Sieve analysis test is conducted in compliance with B.S 882 or B.S 1021 of 1972 to certify the existence of the desire aggregate sizes.

Preparation of concrete and casting of the cubes. Concrete sample are mixed in the ratio 1:1.5:3 first without admixture and afterward with admixture.

The proportion of admixture utilized varied by 5% interval (5,10 and 15% correspondingly).

Three cubes are cast for every percentage change in the proportion of admixture for each of the agent used.

All concrete was produced, cured and tested in the Structural Laboratory of the Civil Engineering Department of the University of Benin

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

(i) Particle size distribution

(ii) Slump test

(iii) Compressive strength

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

3.2.2.1 MIX DESIGN FOR C25 GRADE CONCRETE

Descriptions of the mix:

Characteristic compressive strength of 25 N/mm^2 after 28 days

5 % Defective

Cement: OPC class 42.5

Slump required, 10-30 mm

Maximum free-water/Cement ratio 0.55

Minimum cement content 290 kg/m

Coarse aggregate: uncrushed single sized 20mm

Fine aggregate: Uncrushed with 90% passing 600 µm sieve

Relative density of aggregate: 2.6 (assumed)

Volume of trial mix: 0.001 m3

Step 01: Calculations for The Target Mean Strength

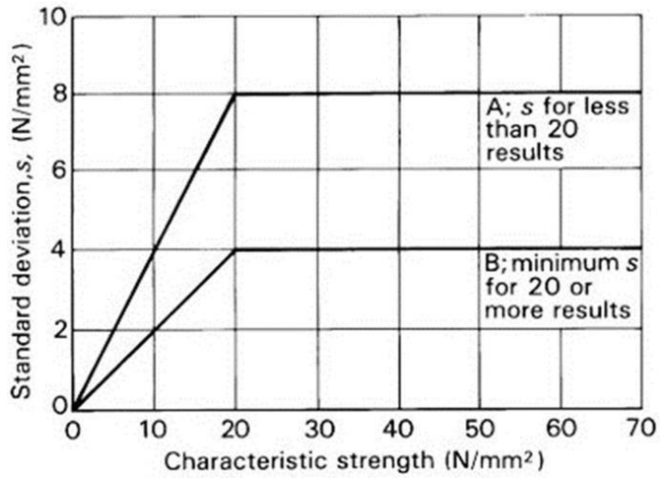

Figure 3.1: Relationship between standard deviation and characteristic strength (El-Reedy, 2020)

Target mean strength = f_m

Specified characteristic strength = f_c , Margin = **K. S**

The standard deviation is 8 Mpa (figure 1)

Specified characteristic strength is 25N/mm^2

k for 5% defectives = 1.64

$fm = fc + k.\, s$

fm = 25 + 1.64 × 8 = 38.12 Mpa

Step 02: Calculation of Water/Cement Ratio

From Table 3.1 the compressive strength for w/c =0.50 is 42 MPa. From Figure 3.2 the w/c for compressive strength of 38.2 MPA is 0.5.

Table3.2 Approximate compressive strengths (MPa) of concrete mixes made with a free water/cement ratio of 0.5

Cement strength class	Type of coarse aggregate	Compressive strengths (N/mm²) Age (days) 3	7	28	91
42.5	Uncrushed	22	30	42	49
	Crushed	27	36	49	56
52.5	Uncrushed	29	37	48	54
	Crushed	34	43	55	61

Throughout this publication concrete strength is expressed in the units N/mm².
1 N/mm² = 1 MN/m² = 1 MPa. (N = newton; Pa = pascal.)

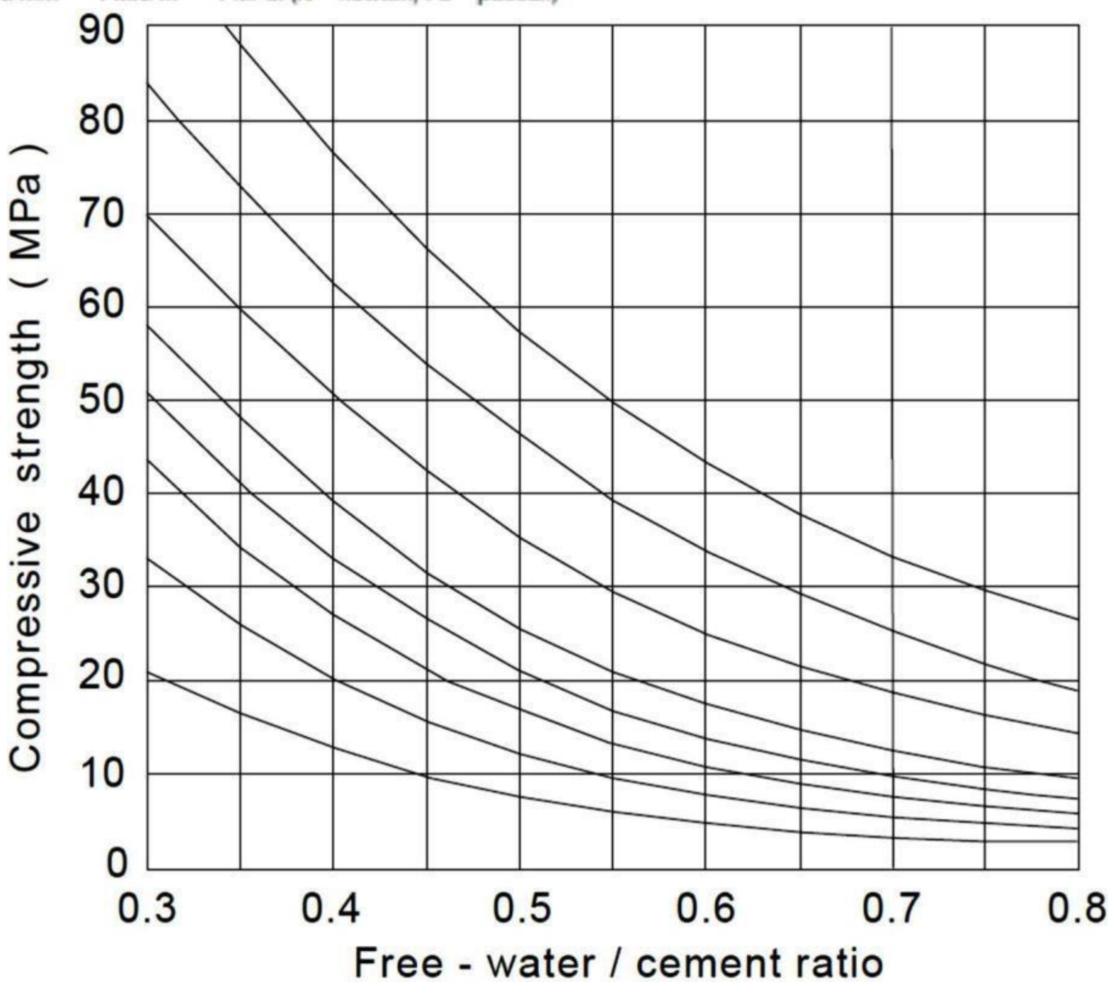

Figure 3.2: Relation between compressive strength and free-w/ ratio (El-Reedy, 2020)

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 222.5 kg/m3 concrete

Slump (mm) Vebe time (s)		0–10 >12	10–30 6–12	30–60 3–6	60–180 0–3
Maximum size of aggregate (mm)	Type of aggregate				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

Table 3.3: Approximate free-water contents (kg/m3) required to give various levels of workability (El-Reedy, 2020)

Step 04: Calculation of cement Content

Water/cement Ratio = 0.5

Cement content = 222.5 ÷ 0.5

= 445 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 – 222.5 – 445 = 1732.5 Kg/m^3 adding 10% for waste gives

1905.75 Kg/m^3

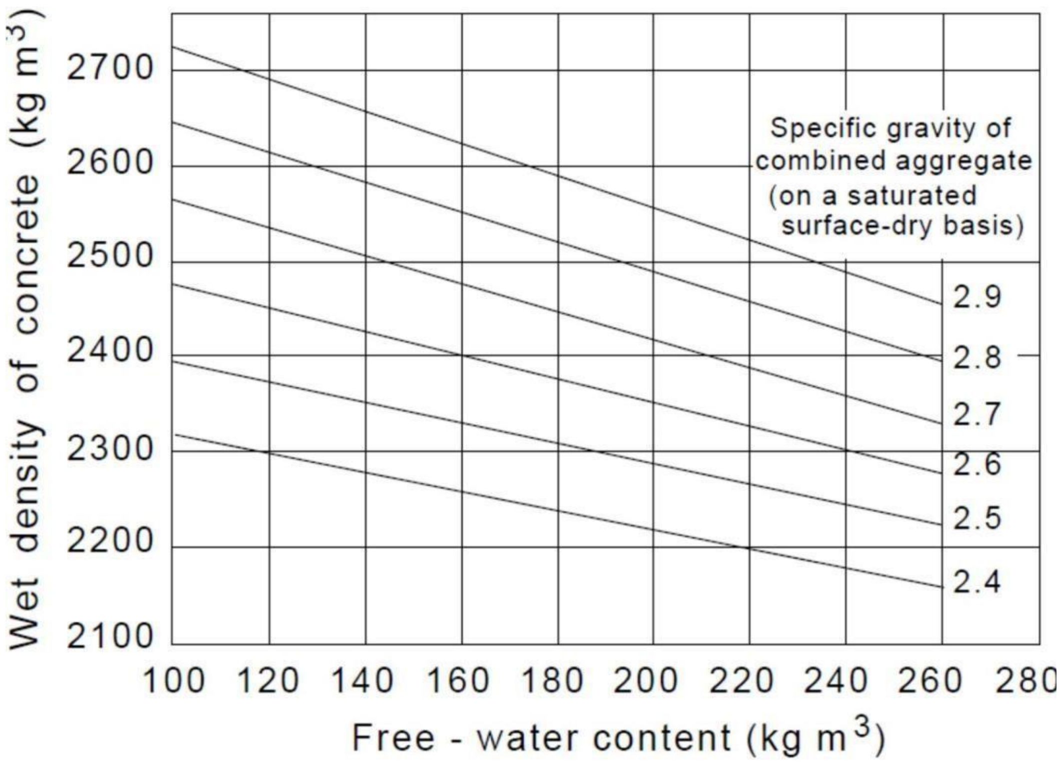

Figure 3.3: Relation between wet density of concrete and free-water content (El-Reedy, 2020)

Step 06: Weight of Fine Aggregate

From Figure 3. The workability level =10-30mm, FM=2.6, w/c=0.5, MSA=20 mm

The percentage of fine aggregates = 35%.

Fine aggregate content = 1905.75×0.35 = 667.5 Kg/m^3

Coarse aggregate content = 1905.75 – 667.5 = 1335Kg/m^3

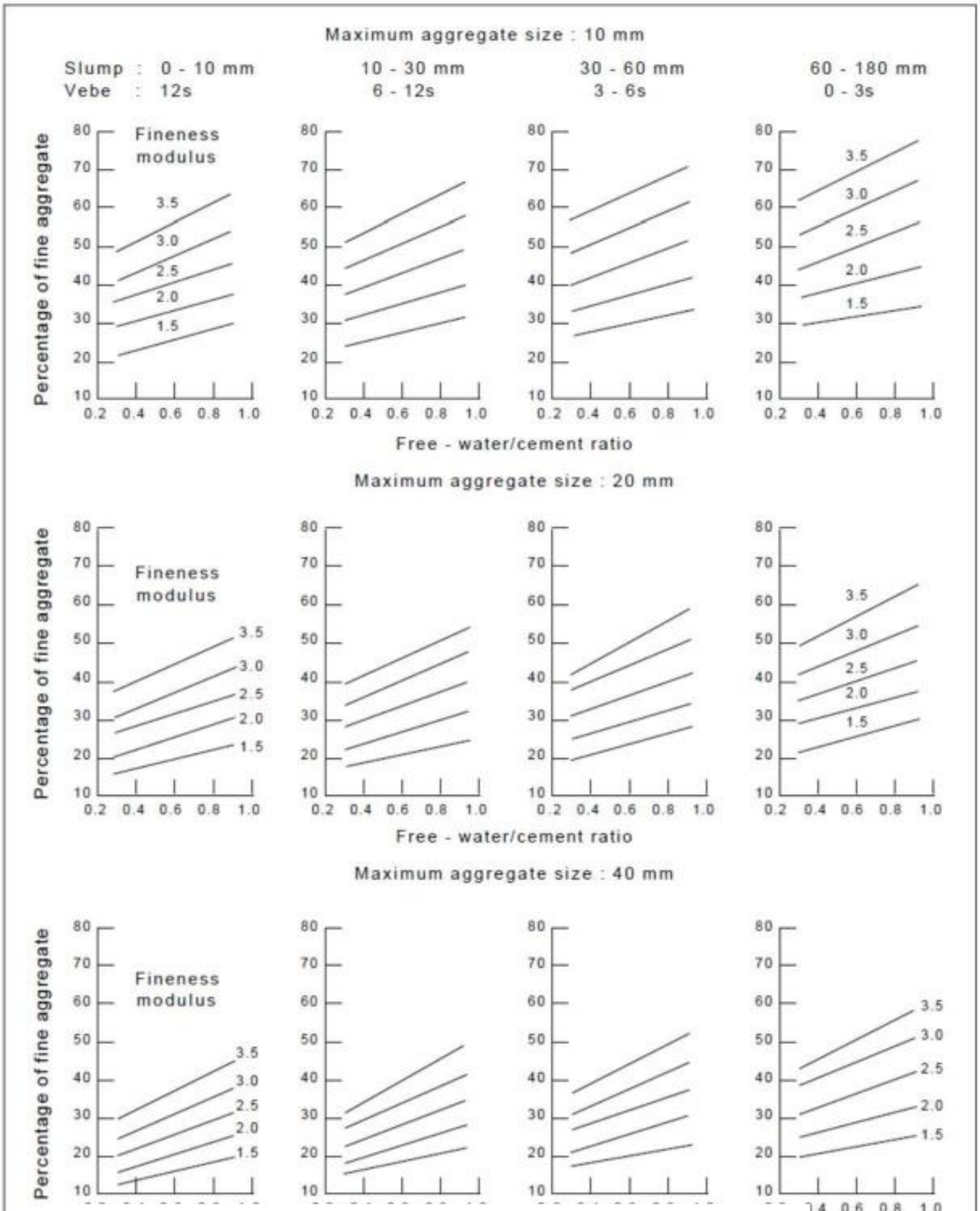

Fig 3.4: Proportions of fine aggregate determined from fineness modulus

Table 3.4: Mix Design (1:1.5:3) Replacement of Fine Aggregate with Plastic

MIX DESIGN SHOWING DIFFERENT PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH PLASTIC						
Percentage Replacement by weight	**No. of cubes**	**Cement (kg)**	**Fine Aggregate (kg)**	**Coarse Aggregate (kg)**	**Water (kg)**	**Plastic (kg)**
For 0%	**9**	**4.45**	**6.675**	**13.35**	**2.225**	**0**
For 5%	**9**	**4.45**	**6.0075**	**13.35**	**2.225**	**0.6675**
For 10%	**9**	**4.45**	**5.34**	**13.35**	**2.225**	**1.335**
For 15%	**9**	**4.45**	**4.6725**	**13.35**	**2.225**	**2.0025**

3.1 MATERIALS

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

i. Cement

ii. Coarse Aggregate

iii. Fine Aggregate

iv. Plastic waste

v. Water

3.1.1 ORDINARY PORTLAND CEMENT (OPC)

The cement used was purchased at Isihor, Benin-Lagos Road, Benin-City Edo state. ASTM Type1 Ordinary Portland cement was used for this experimental study.

3.1.2 PLASTICS

The plastic was gotten from around the locality of Benin city.

3.1.3 FINE AGGREGATE

The fine aggregate was obtained from the same place as the coarse aggregate, which is Isihor, Benin City, along the Lagos-Benin Expressway. The fine aggregate was subjected to a sieve examination using a sieve of 4.75 mm, which was kept on a 600 m sieve and indicated the sample is of zone 11. Hand picking was used to remove any contaminants from the fine aggregate. Before casting, the fine aggregate was let to dry in the air for 72 hours.

3.1.4 COARSE AGGREGATE

The coarse aggregate used in the study was uncrushed granite gotten from Isihor, Benin-Lagos road, Benin City. Coarse aggregate was with nominal maximum size of 20mm. The grading was in accordance with ASTM C33.

3.1.5 WATER

The study's water was pure, drinkable, and devoid of any pollutants or impurities. To ensure uniformity in the mix design, the amount of water used in each mix was 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, was 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 was also used to lubricate the cone during the slump test.

3.2 SAMPLE PREPARATION METHODS

3.2.1 Experimental Tests

All experimental tests were carried out in the structural laboratory unit of the civil engineering laboratory, University of Benin. The concrete cube samples were cast in line with the provisions of BS1881. The tests carried out in the course of this study include; sieve analysis, Slump test, Compressive test.

3.2.1.1 Sieve Analysis

Sieve analysis is a practice used to assess the particle size distribution of a granular material by allowing the material to pass through a series of sieve. A typical sieve analysis involves a nested column of sieves with wire mesh. This test was conducted in accordance with ASTM C136.

Procedures

i. A representative sample is weighed and poured onto the top sieve which has the highest screen opening. (the lower sieve has smaller openings than the ones above). The receiver was located at the base.
ii. The column of sieve was then shaken for some fixed amount of time.
iii. The amount of material retained on each sieve was weighed and recorded.
iv. The mass was then divided by the total mass to determine the percentage retained on each sieve.

3.2.1.2 Slump test

After the mix design was prepared, measurement of materials according to mix design and mixing of materials in the right proportion with a concrete mixer according to mix design chart followed, Slump test was carried out on the concrete using the slump apparatus to determine the slump and workability of the mix. It was carried out in accordance with BS EN 12350- 2:2009.

Procedures

i. The inside of the cone was cleaned and greased.

ii. The mould was placed on a smooth horizontal non-porous base plate.

iii. The mould was filled with concrete in three (3) approximate equal layers.

iv. Each layer was tamped with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould with each tamping penetrating the underlying layer.

v. The excess concrete was removed and the surface leveled with a trowel.

vi. The mortar and leaked water around the mould were cleaned.

vii. The mould was carefully raised from the tamped concrete immediately in a vertical direction.

viii. The difference between the height of the mould and that of the height of tamped concrete was measured and recorded as the slump.

3.2.3 Casting of Concrete Cubes

The freshly mixed concrete was added to the concrete mixer after the slump test, correctly mixed, and then utilized to cast the cubes. The molds were put together. To avoid the formation of a bond between the mold and the concrete, their contact surfaces as well as the interior surfaces we regreased with engine oil. The mixed concrete specimens were then placed within the molds, which were then compressed using a vibrating table for roughly five (5) minutes. After that, a trowel was used to smooth the surfaces. After that, the cubes were kept at room temperature for 24 hours. After 24 hours, the cubes were demolded, and they were promptly cured in potable water for 7, 14, and 28 days, respectively. Compression tests were run on them at the conclusion of each curing phase.

3.2.4 Curing of Concrete Specimens

Curing is an important process to prevent the concrete specimens from losing moisture while it is gaining its required strength. Lack of curing will tends to lead the concrete specimen to perform less well in its strength required. Water curing is by far the most effective and most common type of curing, because it meets the curing requirement of concrete which includes promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. It is pointed out that even if the membrane method is adopted, it is desirable that a certain extent of water curing is done before the concrete is covered with membranes. Inadequate curing will cause the unexpected cracks to appear on the concrete specimens. After 7 and 28 days of curing of each specimen the concrete specimens were removed from the water to conduct hardened properties test of recycled aggregate concrete. However, the cubes and cylinders were taken out at the required day for the compressive and split tensile strength test. water curing can be done in various methods;

i. immersion
ii. ponding
iii. spraying or fogging
iv. wet covering.

For the purpose of this project, curing by immersion was adopted, making use of the curing tank

3.2.5 Compression Test on Concrete Cubes

Each cast concrete cube underwent a test to determine its compressive strength (they were tested at days 7,14 and 28). Each cube was weighed, and the weight was noted. At the conclusion of each curing time, three cubes for each were crushed. According to BS1881-116, the test was conducted.

Procedures

i. The machine was turned on and the gauges were set to zero in order to measure the compressive strength of the concrete cube samples.

ii. Next, the machine' stop screw was lowered to hold the cube samples in place after they had been removed one at a time from the middle of the device (the hydraulic lever was turned until it locks the cube firmly).

iii. After this, the compression machine begins applying compressive force to the cube sample until the cube sample is crushed at a specific maximum force, at which point the dial gauge reads the maximum force. The crushing outcomes are displayed in the following chapter.

3.2.5.1 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

3.2.6 EXPERIMENTAL MIX DESIGN

A significant phase in the creation of concrete technology is mix design, which involves finding out how much of each ingredient to add to produce the correct mix composition and performance. Its purpose is to develop a concrete mix that fits the needs for a given building project, including strength, durability, workability, and other requirements.

To establish the number of materials needed to cast each cube specimen, a mix design for grade 25 concrete was developed. The materials acquired have a ratio of 1:1.5:3, with the slump range chosen falling between 10 and 30 mm in conformity with BS 882 criteria.

3.2.6.1 MIX PROPORTIONS

Four major concrete mixes in total were made:

1. control mix (0% replacement)

2. 5% replacement

3. 10% replacement

4. 15% replacement

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

3.3 PARTICLE SIZE DISTRIBUTION

3.3.1 SIEVE ANALYSIS

In this test, a substance is separated into various particle size classes of decreasing sizes using a succession of test sieves. The beginning mass of the substance is related to the mass of the particle retained on the different sieves. Both numerical and graphical data are supplied regarding the proportions of each sieve that pass through. The goal of the test was 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

Procedure

1. If any particles get caught in the apertures of the sieves, clean them using a cleaning brush.

2. The weight of each sieve and receiving pan shall be recorded.

3. Record the specimen's weight after weighing it.

4. Put the sieves in succession such that the bigger openings go to the top and the smaller openings go to the bottom.

5. Store the specimen with the weight recorded on the upper sieve, and then transfer the complete sieve stack into the sieve shaker (remember to save the reception pan and lid).

6. Take note of the time and let the shaker run for 10 to 15 minutes.

7. After removing the sieve stack from the shaker, weigh each sieve and receiving pan independently.

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).

3.4.1 APPARATUS

The apparatus used include:

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

b. Base plate

c. Measuring tape

d. Tamping rod

3.4.2 PROCEDURES

1. Make sure that the internal surface of the slump cone is dry, clean, and devoid of any cement residue that has set.
2. lubricate its internal surface with oil/grease to stop the slump cone from adhering and for easy removal
3. Make sure the droop cone is properly 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 roughly a fourth 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, wipe the base plate and the bottom of the cone, removing any residual concrete.

10. Raise the slump cone vertically from the newly laid concrete and lay it gently next to the concrete.

11. For measuring and recording purposes, lay the tamping rod atop the cone and align it with the concrete mound's height.

12. A measuring tape was used to determine the slump, which is the difference between the cone's height and the height of the concrete specimen.

3.4.3 COMPRESSIVE STRENGTH TEST

Compressive strength testing is a key test for determining how well concrete can support loads. A compression testing apparatus was utilized in the process. Cubic samples were examined after 7,14, and 28days of cure for every mixture.

3.4.4 PROCEDURE

1. The cubes were taken out of the curing tank at various stages of curing.

2. The cubes were 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 were placed so that the base plate of the compression machine was in the center. The equipment is activated and measurements are obtained as soon as the specimen fails.

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

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter offers a complete analysis of the results gained from the experiments conducted in Chapter 3. The chapter is split into sections, each concentrating on particular qualities and elements of concrete performance.

The tests carried out include:

(i) Sieve Analysis Test

(ii) Slump Test

(iii) Compressive Test

For all tests, the coarse aggregate was replaced with plastic at 0%, 5%, 10%, and 15% respectively.

The results are interpreted in light of the study objectives and compared with those of conventional concrete mixes. The discussion section explores the implications of the findings, identifies trends or patterns observed, and offers insights into the performance of plastic-aggregate concrete in comparison to traditional concrete formulations.

4.1 COMPRESSIVE STRENGTH TEST

This study's main objective was to evaluate compressive strength. The concrete specimens were tested for compressive strength once the curing phase was over. A hydraulic compression testing apparatus was used for this testing.

Every specimen was carefully positioned in between the compression testing machine's platens. Every effort was made to guarantee that the specimen received the load uniformly. The specimen was subjected to a steady, progressive load until it broke. The specimen's measurements and the load at failure were noted.

The concrete specimen's compressive strength is determined using the data that was recorded during the test.

To get this value, divide the maximum applied load by the cross-sectional area of the specimen. The formula is simple to use:

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

Water-Cement ratio used: $\frac{\textbf{Water}}{\textbf{Cement}}$ **= 0.5**

Table 4.1: Table Showing Compressive strength of 0% Percentage Replacement

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	A	**2.424**	**2424**	**199.2**	19.92	2433	**19.723**
	B	**2.461**	**2461**	**187.32**	18.732		
	C	**2.413**	**2413**	**205.17**	20.517		
14	A	**2.414**	**2414**	**265.033**	26.5033	2493	**25.6724**
	B	**2.543**	**2543**	**254.17**	25.417		
	C	**2.522**	**2522**	**250.97**	25.097		
28	A	**2.454**	**2454**	**261.13**	26.113	2287	**26.06**
	B	**2.431**	**2431**	**258.79**	25.879		
	C	**2.409**	**2409**	**261.88**	26.188		

Table 4.2: Table Showing Compressive strength of 5% Percentage Replacement

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	A	**2.543**	**2543**	**185.45**	18.545	2523.667	**18.591**
	B	**2.501**	**2501**	**191.02**	19.102		
	C	**2.527**	**2527**	**181.26**	18.126		
14	A	**2.402**	**2402**	**208.38**	20.838	2420.667	**21.8927**
	B	**2.451**	**2451**	**214.23**	21.423		
	C	**2.409**	**2409**	**234.17**	23.417		
28	A	**2.541**	**2541**	**233.84**	23.384	2494.667	**23.5043**
	B	**2.503**	**2503**	**249.51**	24.951		
	C	**2.44**	**2440**	**221.78**	22.178		

Table 4.3: Table Showing Compressive strength of 10% Percentage Replacement

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	A	**2.376**	**2376**	**142.19**	14.219	2359	**13.682**
	B	**2.355**	**2355**	**135.26**	13.526		
	C	**2.345**	**2345**	**133.01**	13.301		
14	A	**2.388**	**2388**	**165.05**	16.505	2381	**15.0103**
	B	**2.374**	**2374**	**144.24**	14.424		
	C	**2.381**	**2381**	**141.02**	14.102		
28	A	**2.401**	**2401**	**201.13**	20.113	2412	**18.98**
	B	**2.451**	**2451**	**188.68**	18.868		
	C	**2.385**	**2385**	**179.59**	17.959		

Table 4.4: Table Showing Compressive strength of 15% Percentage Replacement

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	A	**2.301**	**2301**	**90.07**	9.007	2303.67	**9.25433**
	B	**2.298**	**2298**	**100.44**	10.044		
	C	**2.312**	**2312**	**87.12**	8.712		
14	A	**2.354**	**2354**	**125.67**	12.567	2328	**12.38**
	B	**2.343**	**2343**	**112.88**	11.288		
	C	**2.287**	**2287**	**132.85**	13.285		
28	A	**2.321**	**2321**	**150.41**	15.041	2294	**14.5217**
	B	**2.293**	**2293**	**147.21**	14.721		
	C	**2.268**	**2268**	**138.03**	13.803		

Table 4.4a: Table Showing Average Compressive strength at different Percentage Replacement

Specimen (Cube 100mm X 100mm X100 Mm)	**Avg Compressive Strength Results (7 Days)**	**Avg Compressive Strength Results (14 Days)**	**Avg Compressive Strength Results (28days)**
CONTROL	19.723	25.6724	26.06
5% REPLACEMENT	18.591	21.8927	23.5043
10% REPLACEMENT	13.682	15.0103	18.98
15% REPLACEMENT	9.25433	12.38	14.5217

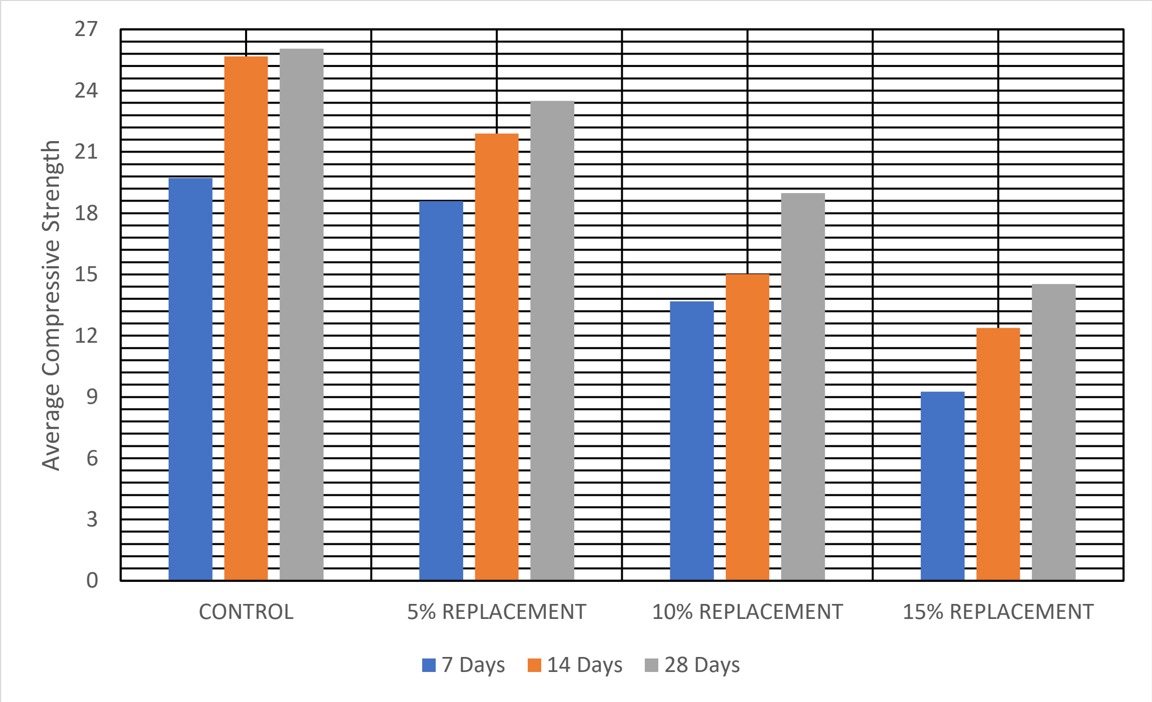

Fig 4.3 showing the average maximum strength obtained after curing period for each percentage replacement

4.2 Discussion of the Compression Result

The compression test results, as presented in Tables 4.1 to 4.4, demonstrate the effect of various percentages of sand replacement with plastic material on the compressive strength of concrete samples. The control sample, with no replacement, exhibited the highest compressive strength throughout the curing periods of 7, 14, and 28 days. As the percentage of sand replacement increased, there was a noticeable decrease in compressive strength. Notably, the replacement of 5% of sand with plastic material showed a gradual decrease, while beyond 10%, the decrease became more significant. This trend is attributed to the inability of plastic waste aggregate to effectively interact with the cement paste, unlike natural aggregate.

4.3 Result from Sieve Analysis for fine aggregate

Total Mass of sand tested = 100.00g

Table 4.5: Particle size distribution for fine aggregate

Sieve Size (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
2.36	0.1	0.1	0.1	99.9
2.00	0.3	0.3	0.4	99.6
1.18	5	5	5.4	94.6
600	10.4	10.4	15.8	84.2
425	23.4	23.4	39.2	60.8
300	17.2	17.2	56.4	43.6
212	34	34	90.4	9.6
150	6.4	6.4	96.8	3.2
75	3	3	99.8	0.2
Pan	0.1	0.1	99.9	0.1

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

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

% loss < 0.5

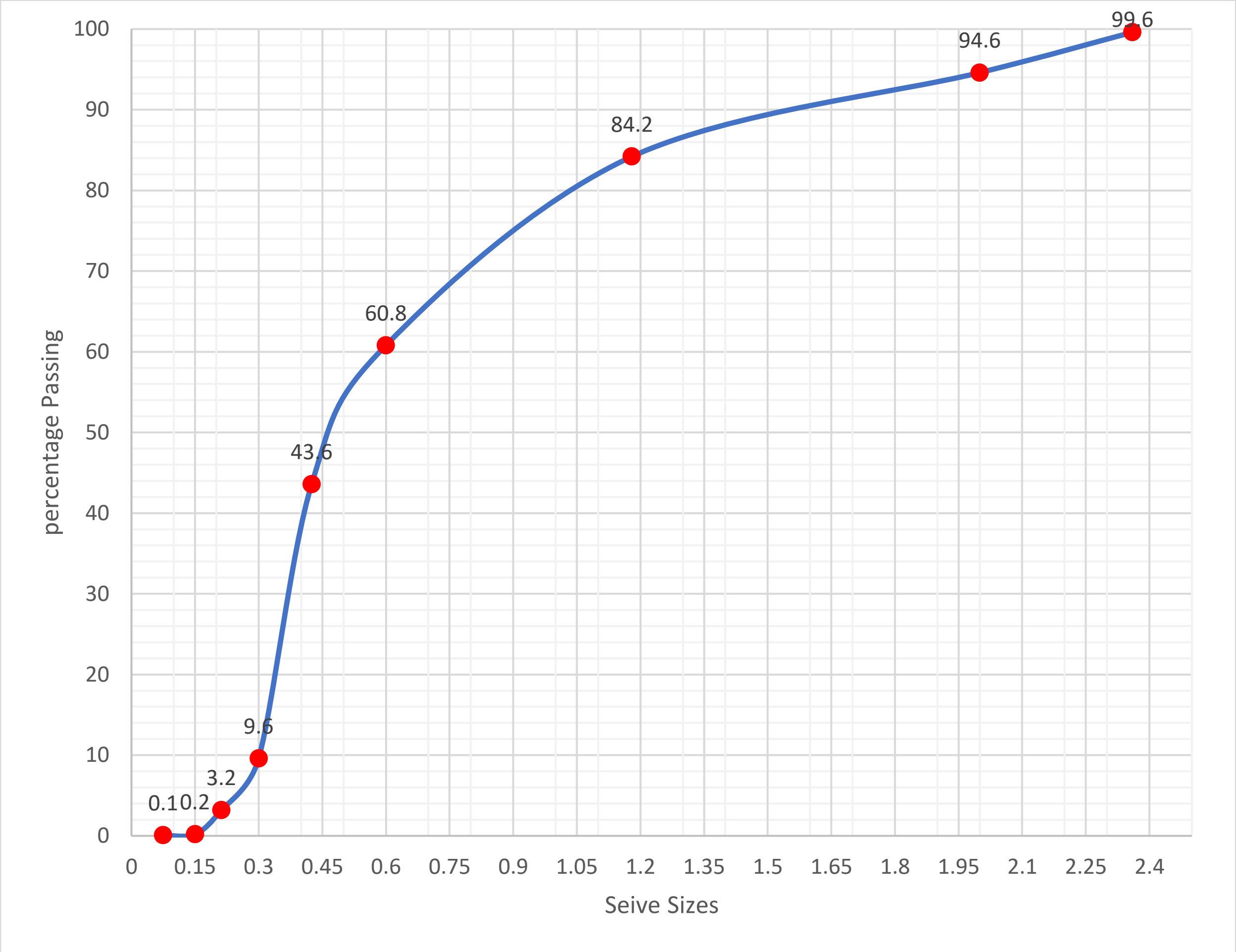

Fig 4.4: Particle Distribution of the Natural Fine aggregate

4.4 Result of Sieve Analysis for the Plastic

Total Mass Tested = 100 g

Table 4.6: Particle size distribution for Plastic

Sieve Size(mm)	**Mass Retained(g)**	**Percentage Retained (%)**	**Cumulative percentage** Retained (%)	**Percentage Passing (%)**
2.36	**0.55**	**0.55**	**0.55**	**99.45**
2.00	**1.18**	**1.18**	**1.73**	**98.27**
1.18	**6.65**	**6.65**	**8.38**	**91.62**
600	**34.19**	**34.19**	**42.57**	**57.43**
425	**18.68**	**18.68**	**61.25**	**38.75**
300	**22.58**	**22.58**	**83.83**	**16.17**
212	**13.87**	**13.87**	**97.7**	**2.3**
150	**0.63**	**0.63**	**98.33**	**1.67**
75	**1.5**	**1.5**	**99.83**	**0.17**
Pan	**0.15**	**0.15**	**99.98**	**0.02**

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

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

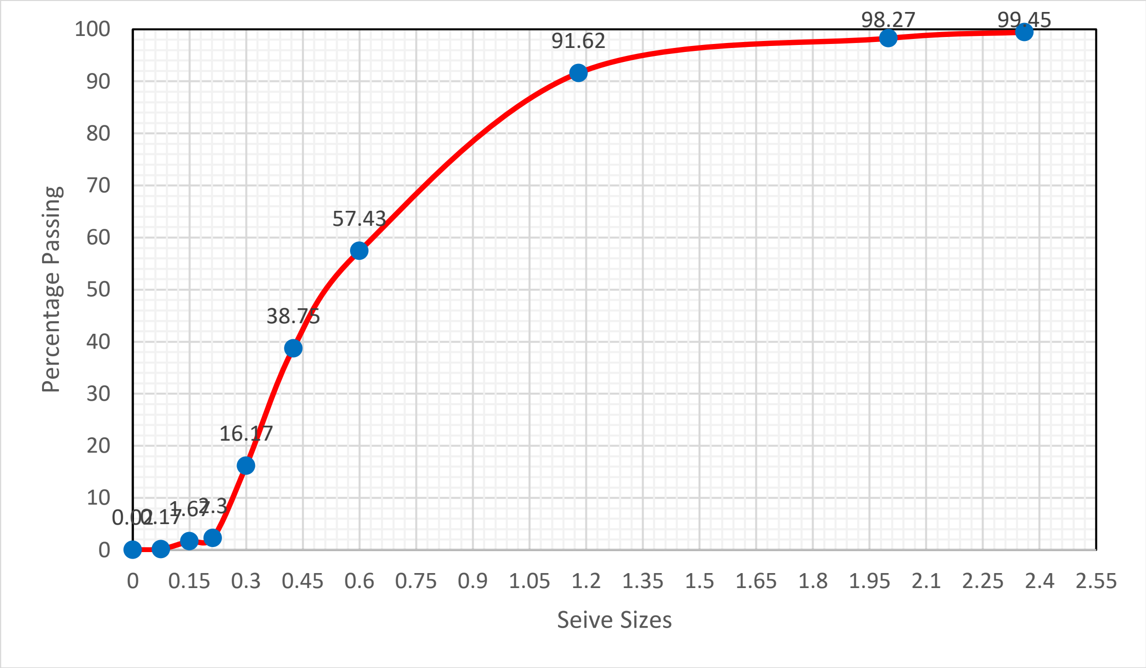

Fig 4.5: Particle Distribution for the Plastic

4.5 Discussion of the Results obtained from the Sieve Analysis

The sieve analysis results for both fine aggregate (natural sand) and plastic material are presented in Tables 4.5 and 4.6, along with corresponding particle distribution figures. Interestingly, the particle distributions of both materials exhibit similar textural profiles, indicating compatibility for comparison. This similarity underscores the potential of plastic waste as a substitute for natural sand in concrete production.

4.6 Results from Slump Test

Table 4.7: Results from Slump test

Sample No	Slump Value (mm)
CONTROL	21
5% REPLACEMENT	18
10% REPLACEMENT	15
15% REPLACEMENT	13

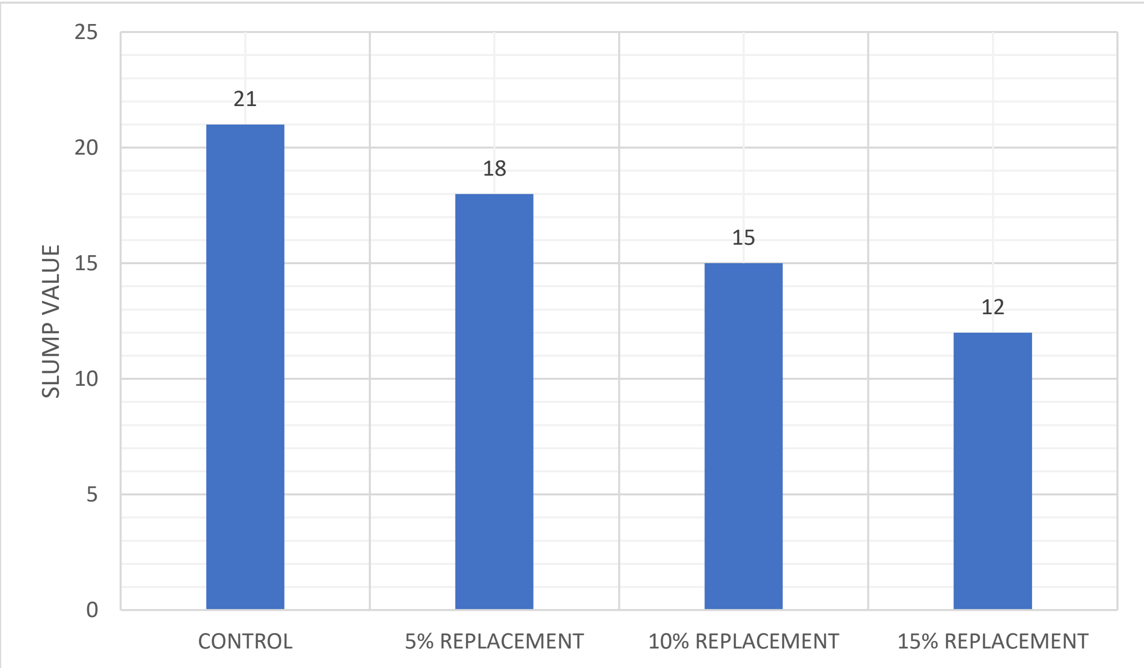

Fig 4.6: Slump Variation with increase in % replacement

4.7 Discussion of the Results obtained from the Slump Test

Fig 4.1 shows that the slump of the fresh concrete decreased with increase in the replacement of the fine aggregate. This implies that the presence of plastic in the concrete decreased its workability. However, the 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).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 CONCLUSION

Recycling of plastic trash with river sand decreases its negative environmental impact of river sand quarries, reduces the depletion of natural resources.

Reuses the waste plastic products of plastic industry and minimizes the amount of trash connected with these businesses.

Replacements of river sand with varied percentages of plastic waste (5%, 10% and 15% of partial replacement) did not have a major detrimental effect on the uniformity of fresh concrete qualities of concrete up to 15% of replacement. The Reductions were not considerably changed by the percentage replacement of regular concrete with plastic partially replaced concrete.

Results of this test program have a favorable impact on the employment of waste plastic fine aggregate in concrete making.

Based on the findings of this study, it can be concluded that the replacement of natural sand with plastic waste aggregate in concrete production leads to a reduction in compressive strength. However, the similarity in particle distribution between natural sand and plastic material suggests the potential for utilizing plastic waste as a partial replacement for sand without significant compromise in textural properties.

5.1 RECOMMENDATIONS

1. Further research should focus on optimizing the incorporation of plastic waste aggregate to mitigate the observed reduction in compressive strength.

2. Long-term durability studies are necessary to assess the performance of concrete specimens containing plastic waste aggregate under various environmental conditions.
3. Collaboration between academia, industry, and government agencies is essential to develop standardized protocols for incorporating plastic waste in concrete production while ensuring structural integrity and sustainability.

REFERENCES

AL-Buhaisi, K.U.: Investigating the use of recycled plastics as shrinkage reinforcement in non-structural concrete slabs. M.Sc. thesis, The University of Gaza (2013)

Al-Manaseer, A.A., Dalal, T.R.: Concrete containing plastic aggregates. Concrete. Int. 19, 47–52 (1997)

Aysha Zeneeb Majeed, Tressa Kurian, Babitha Davis, Shaun Thomas Alex, Kevin Shelly Fernandez & Amala V. Mathew. (2018). Partial Replacement of Aggregates with Granulated Waste Plastic in Solid Concrete Blocks—An Intensive Study. In Green Buildings and Sustainable Engineering (pp. 405-415). SpringerLink1

Ganesan, N., & Rajasekaran, S. (2018). "Experimental Study on Partial Replacement of Fine Aggregate with Plastic Waste in Concrete." Materials Today: Proceedings, 5(1), 13302-13308.

Ismail, Z.Z., Al-Hashmi, E.A.: Use of waste plastic in concrete mixture as aggregate replacement. Waste Manage. 28, 2041–2047 (2008)

Khan, F. M., & Al-Gahtani, A. S. (2017). "Effect of Partial Replacement of Fine Aggregate with Plastic Bottles on the Properties of Concrete." Journal of King Saud University - Engineering Sciences, 29(4), 377-382.

Manjunath, M., & Surya Prakash, V. (2017). "Experimental Study on Partial Replacement of Fine Aggregate with Plastic Granules in Concrete." International Journal of Engineering Research and Applications, 7(4), 26-30.

Rahman, M.M., Islam, M.A., Ahmed, M., Salam, M.A.: Recycled polymer materials as aggregates for concrete and blocks. J. Chem. Eng. IEB ChE. 27(1), 53–57(2012),

S. S. Jamkar, S. S. Kadam, & S. S. Kadam. (2019). Experimental Study on Partial Replacement of Fine Aggregate with Plastic Waste in Concrete. International Journal of Innovative Technology and Exploring Engineering, 8(7), 134-1372.