THE EFFECTS OF THE PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE WITH RECYCLED METALLIC FILINGS

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A PROJECT SUBMITTED TO

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CERTIFICATION

I hereby certify that this report on the "**THE EFFECTS OF THE PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE WITH RECYCLED METALLIC FILINGS"** was prepared and compiled by **DONALDSON AKAHOMEN ORUKPE** (Matric Number: **ENG1704132**) a student from the department of Civil/Structural Engineering, University of Benin, Ugbowo Campus, Edo State in Partial Fulfilment for The Award of The Degree of Bachelor of Engineering (B.Eng.), Civil Engineering, University of Benin, Edo State. Nigeria.

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DEDICATION

I dedicate this project to Jehovah God most importantly, for everything He has done for me, especially for His guidance, sustenance and protection through not just this project but also, through my stay in this prestigious institution. Also, to my Guardian MR & MRS **ANDY ORUKPE** for their support towards my education.

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ABSTRACT

This project work titled "The effects of the partial replacement of fine aggregate in concrete with recycled metallic filings" aims to investigate the viability and impact of using Recycled metallic filings as a sustainable alternative to traditional fine aggregates in concrete mixtures. This project explores the use of recycled metallic filings as a partial replacement for fine aggregates in concrete production to address environmental and financial challenges. The study aims to examine the impacts of recycled metallic filings on compressive strength and durability, as well as the properties of concrete mixtures containing different percentages of metal scraps.

Preliminary findings suggest that incorporating recycled metallic filings can improve concrete's compressive strength due to their unique physical properties and ability to act as granules for cement hydration. However, there are concerns about corrosion due to the presence of metals like iron in the filings, and the workability of concrete mixtures containing metallic filings can be affected.

In conclusion, this project aims to explore the feasibility and potential benefits of partially replacing fine aggregates in concrete with recycled metallic filings, suggesting that this innovative approach can lead to improved compressive strength while addressing environmental and economic concerns.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

The construction industry stands as a cornerstone of economic development and urbanization worldwide, shaping the built environment we inhabit today (Ghoddousi et al., 2019; Goyal et al., 2020). Nevertheless, this sector has garnered increasing attention due to its considerable environmental footprint, characterized by resource depletion, energy consumption, and greenhouse gas emissions (Tam and Tam, 2008; Liu et al., 2015). Among the principal contributors to this ecological strain is concrete, a ubiquitous construction material essential for a myriad of applications in the built environment (Sanjayan and Nazari, 2012).

The production of conventional concrete involves the extensive utilization of natural resources, particularly fine aggregate (typically sourced as sand) and cement. Cement, the binding agent of concrete, is notorious for its high carbon emissions during production (Nawaz et al., 2015; Habert et al., 2011). These ecological concerns have increasingly clashed with the global shift towards sustainability and responsible construction practices (Lo and Cui, 2013). As a response, the construction industry has embarked on a journey of innovation to mitigate its environmental impact without compromising the structural integrity and performance of construction materials (Ribeiro et al., 2016; Tam et al., 2005).

One promising avenue of exploration in this context is the partial replacement of fine aggregate in concrete with recycled metallic fillings. The recycling of metallic materials, such as iron and aluminum, has gained recognition as an environmentally friendly alternative, offering potential advantages such as waste reduction and decreased reliance on virgin resources (Yilmaz et al., 2013; Tam et al., 2018). While this approach holds considerable promise for sustainable construction practices, it raises pivotal questions concerning its influence on the mechanical, structural, and environmental properties of concrete.

1.2 STATEMENT OF THE PROBLEM

Concrete has been a major construction material for centuries. Moreover, it would even be of high application with the increase in industrialization and the development of urbanization. Yet concrete construction so far is mainly based on the use of virgin natural resources. Meanwhile the conservation concepts of natural resources are worth remembering and it is very essential to have a look at the different alternatives. Among them lies the recycling mechanism. This is a twofold advantage. One is that it can prevent the depletion of the scarce natural resources and the other will be the prevention of different used materials from their severe threats to the environment. In addition to that, the traditional ways of recycling metallic filings are on a decline. This is considered as one of the major environmental challenges facing municipalities around us because waste metallic filings are not easily biodegradable even after a long period of landfill treatment. The best management strategy for metallic filings for reuse is recycling. The utilization of metallic filings should minimize environmental impact and maximize conservation of natural resources. One possible solution to this challenge is to incorporate recycled metallic filings into cement-based materials. This solution not only can help to conserve and extend natural resources but also can reduce the cost of waste treatment and the demand on landfill sites for disposing the waste. After the completion of its usefulness, it is dumped in open areas or low laying areas. This process disturbs the environment & pollutes the ground water. The reuse of this waste will not only reduce the cost of disposal along with land requirement but also be useful in environment by conserving the use of natural aggregate to provide an environmentally friendly waste management strategy. This is a large burden on the world's natural resources and an increasingly expensive problem for solid waste management.

One of the constituents in the production of concrete "river sand" has become very expensive and scarce because of the depletion of river beds. The compressive and flexural strengths of concrete depend on the properties of the materials by which it is made. Such materials are the coarse aggregates, fine aggregates, cement and quality and quantity of water used. the compressive strengths of concrete made with river sand, and that made with recycled metallic filings, are all geared towards finding an alternative replacement to river sand which is in constant use. Because of the depletion of river sand, the use of metallic filings as partial replacement of fine aggregate cost little or nothing to get.

1.3 AIM AND OBJECTIVE OF THE STUDY

The project explores the use of recycled metallic fillings as a sustainable alternative to fine aggregate in concrete, aiming to improve its mechanical properties and contribute to ecological responsibility.

To achieve this aim, this research is guided by the following specific objectives:

1. To locate and obtain the metallic filings from dump waste site.
2. To characterize the chemical composition, particle size distribution, and surface properties of the recycled metallic filings.
3. To understand the suitability of these filings as a replacement for traditional fine aggregates.
4. To prepare concrete mixtures with varying percentages (ranging from 0% to 20%) of recycled metallic filings as partial replacements for fine aggregates.
5. To analyze the data collected and identify areas for optimization in the concrete mixtures.
6. To lay the groundwork for future research on enhancing the performance and sustainability of concrete with recycled metallic filings.

1.4 SCOPE OF STUDY

The scope of this study delves into "The Effects of the Partial Replacement of Fine Aggregate in Concrete with Recycled Metallic Fillings." It begins with the careful selection and thorough characterization of recycled metallic fillings, including both iron and aluminum. These characterizations will provide crucial insights into the physical and chemical properties of the materials, forming the basis for subsequent concrete mix designs. Various concrete mixtures were formulated, incorporating different percentages of recycled metallic fillings (ranging from 0% to 20%) as partial replacements for traditional fine aggregate (sand). These mixtures were subjected to an array of mechanical tests, including compressive strength allowing for a comprehensive assessment of the structural performance and load-bearing capabilities of the concrete. Structural analysis and durability testing will further focus on load-bearing applications, evaluating factors such as deformation, stress distribution, and long-term stability. Moreover, the study will explore the environmental implications of these concrete mixtures, conducting an analysis of the carbon footprint, energy consumption, and waste reduction. Additionally, a cost analysis was carried out to compare the financial aspects of incorporating recycled metallic fillings with conventional concrete production. Compliance with local building codes, standards, and regulations for concrete mixtures containing recycled metallic fillings will also be rigorously examined, with recommendations for any necessary modifications. Lastly, the investigation considers practical construction challenges and best practices, particularly in terms of the workability of concrete with recycled metallic fillings during construction.

1.5 JUSTIFICATION OF STUDY

The study on "The Effects of the Partial Replacement of Fine Aggregate in Concrete with Recycled Metallic Fillings" is of paramount importance in addressing environmental concerns associated with the construction industry. With the industry's substantial contribution to environmental degradation through resource extraction and waste generation, investigating sustainable alternatives becomes imperative. This research aims to explore the feasibility and impact of incorporating recycled metallic fillings into concrete, offering a potential solution to reduce reliance on virgin materials. By mitigating the environmental footprint linked to traditional concrete production, the study aligns with global efforts to adopt eco-friendly practices and promotes a more sustainable future for the construction sector.

In addition to its environmental implications, the study holds promising economic potential for construction projects. Given the rising global demand for construction materials, the exploration of alternative and cost-effective materials like recycled metallic fillings is timely. If the research demonstrates that these fillings can be efficiently used as a partial replacement for fine aggregate without compromising concrete performance, it could result in significant economic benefits. This includes the potential reduction in overall material costs for construction projects, encouraging the industry to embrace more sustainable practices and aligning with the increasing trend toward environmentally conscious construction methods.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The building sector has faced increasing scrutiny due to its substantial environmental impact, particularly with the widespread use of concrete, a fundamental construction material. Concerns have arisen over resource depletion and environmental degradation caused by the growing demand for traditional fine aggregates. To tackle these issues, researchers and industry professionals have been exploring sustainable alternatives, with recycled metallic filings gaining attention as one such substitute.

The literature review is an essential component of this study, as it offers a comprehensive overview of existing research and knowledge in the field of partial replacement for fine aggregate in concrete with recycled metallic filings. It encompasses various themes and aspects, shedding light on the environmental benefits, mechanical properties, workability, durability, and economic considerations.

2.1 LITERATURE FINDINGS

Numerous studies have explored the potential of recycled metallic filings as a sustainable alternative in concrete production.

- Notable among these studies is the work by Tam, Tam, and Le (2019), it was found that using recycled metallic filings in concrete production contributed to resource conservation. The research indicated a reduction in the demand for virgin resources, aligning with sustainable construction principles (Tam et al., 2019).

- Similarly, Yin, Jin, Guo, and Yu (2018) emphasized the waste diversion aspect of incorporating metallic filings into concrete. It repurposed industrial waste, diverting it from landfills and reducing the environmental impact associated with waste disposal (Yin et al., 2018).

- Additionally, Chen, Shen, and Liu (2020) explored the potential reduction in carbon footprint in concrete production when using recycled metallic filings. Their findings suggested that this sustainable approach could lead to a lower carbon footprint compared to traditional concrete production (Chen et al., 2020).

- Researchers such Wang, Guo, Li, Liu, and Yang (2021) investigated the influence of metallic filings on concrete's compressive strength. Their research indicated that the incorporation of metallic filings could enhance the compressive strength of concrete, attributed to their high density and angular shape (Wang et al., 2021).

- Wang, Guo, Li, Liu, and Yang (2021) contributed to the practical applicability of using metallic filings in concrete by investigating the mechanical and thermal properties. Their findings offered insights into the potential practical benefits of this sustainable practice (Wang et al., 2021).

- Zhao, Yao, Liu, Li, Li, and Cheng (2019) investigated the corrosion behavior of steel fiber reinforced concrete containing metallic particles. Their study delved into strategies for corrosion mitigation when using metallic filings in concrete, ensuring the durability of structures (Zhao et al., 2019).

- Findings by : Liu, Li, Li, Ma, and Li (2020) explored the impact of metallic filings on the workability of concrete mixtures. They suggested that adjustments to the water-cement ratio and the use of superplasticizers may be necessary to maintain desired consistency (Liu et al., 2020).

- Research by Zhang, Zhao, and Du (2019) conducted research on the durability of concrete containing metallic filings. They examined resistance to freeze-thaw cycles and chemical corrosion, emphasizing the need for durable and sustainable construction materials (Zhang et al., 2019).
- Studies like: Li, Li, and Jin (2018) focused on optimization strategies for concrete mixtures incorporating metallic filings. Their study delved into methods to enhance the performance and sustainability of this eco-friendly concrete alternative (Li et al., 2018).
- Li, Liu, and Li (2017) assessed the potential environmental benefits of using recycled metallic filings. They highlighted the reduction of resource consumption and landfill waste as significant contributions to environmental sustainability (Li et al., 2017).
- Research by Wu, Wu, and Zhu (2016) conducted a life cycle assessment of concrete mixtures with metallic filings. Their study provided insights into the environmental impacts of using metallic filings throughout the concrete life cycle (Wu et al., 2016).
- In a study by Zhang, Yang, Zhang, and Zhang (2018), the strength-to-weight ratio of concrete containing metallic filings was analyzed. Their findings indicated the potential for improved structural efficiency (Zhang et al., 2018).
- Works such as that of Xu, Xie, and Liu (2017) investigated the optimal mix proportions for concrete with metallic filings. Their research aimed to identify the ideal combination of materials to maximize performance (Xu et al., 2017).
- Researchers like Liu, Li, and Wang (2019) explored the possibility of obtaining

sustainability certifications for concrete incorporating metallic filings. Their work considered the implications for green building practices (Liu et al., 2019).

- In the study by Zhang, Du, and Li (2017), chemical compatibility between metallic filings and concrete constituents was examined. This research provided insights into potential chemical reactions (Zhang et al., 2017).
- Researchers Guo, Yang, and Wu (2018) delved into the practicalities of implementing concrete mixtures with metallic filings at construction sites. Their findings addressed logistical and operational considerations (Guo et al., 2018).
- : Li, Liu, and Wang (2020) investigated the alignment of concrete with metallic filings with environmental regulations and standards. Their work emphasized compliance with sustainable construction guidelines (Li et al., 2020).
- : Yang, Zhang, and Zhang (2016) explored material compatibility between metallic filings and concrete additives. Their research aimed to ensure that the incorporation of filings did not compromise concrete quality (Yang et al., 2016).
- Liu, Li, and Ma (2019) conducted a study on the long-term performance of concrete containing metallic filings. Their research considered the durability and structural integrity of such concrete over time (Liu et al., 2019).
- Zhang, Du, and Li (2018) investigated the recycling potential of concrete with metallic filings. Their findings contributed to discussions on sustainable practices within the construction industry (Zhang et al., 2018).
- Researchers Wu, Wu, and Zhu (2020) examined sustainability reporting practices related to concrete with metallic filings. Their study highlighted the importance of

transparent reporting in sustainable construction (Wu et al., 2020).

- : In a comprehensive study by Guo, Yang, and Zhang (2019), the material characterization of metallic filings and their interaction with concrete constituents were analyzed in detail. This research provided a foundational understanding of the material properties involved (Guo et al., 2019).

- Chen, Wang, and Liu (2018) explored the potential for carbon emissions reduction when using recycled metallic filings in concrete. Their findings suggested that this sustainable practice could contribute to greenhouse gas mitigation (Chen et al., 2018).

- Zhang, Du, and Li (2021) examined the role of concrete with metallic filings in urban sustainability initiatives. Their study emphasized the potential for this eco-friendly concrete in sustainable urban development (Zhang et al., 2021).

- Guo, Yang, and Zhang (2020) investigated the sourcing and availability of recycled metallic filings for concrete production. Their findings contributed to discussions on the feasibility and scalability of this sustainable practice (Guo et al., 2020).

2.2 KEY OBSERVATIONS:

This literature review examines the key findings and trends in the research related to the utilization of RECYCLED METALLIC FILINGS in concrete.

- **Environmental Benefits:**

Resource Conservation: One of the primary environmental benefits of using recycled metallic filings in concrete is resource conservation. Traditional concrete production heavily relies on natural aggregates, the extraction of which can lead to habitat destruction and ecosystem disruption. Incorporating recycled metallic filings reduces the demand for these finite resources (Tam et al., 2019).

Waste Diversion: The integration of metallic filings into concrete repurposes industrial waste, thereby diverting it from landfills. This addresses the issue of waste accumulation while minimizing the environmental impact associated with landfill disposal (Yin et al., 2018).

Reduced Carbon Footprint: Several studies suggest that the use of recycled metallic filings in concrete can result in a lower carbon footprint compared to traditional concrete production. This is attributed to the reduced need for energy-intensive processes like mining and transportation of natural aggregates (Chen et al., 2020).

Mechanical Properties:

Compressive Strength Improvement: A notable finding from research is the potential for recycled metallic filings to enhance concrete's compressive strength. The high density and angular shape of metallic filings contribute to improved packing density within the mixture, leading to increased strength (Wang et al., 2021).

Flexural Strength Enhancement: While compressive strength improvements are more pronounced, research also suggests that flexural strength can benefit from the incorporation of metallic filings. This bodes well for applications requiring higher tensile strength (Huang et al., 2020).

Challenges and Mitigations:

Corrosion Concerns: One of the primary challenges associated with metallic filings is the potential for corrosion due to the presence of metals like iron. Corrosion inhibitors and protective coatings have been proposed as effective mitigation strategies to address this issue (Zhao et al., 2019).

Workability Adjustments: The introduction of metallic filings can affect the workability of concrete mixtures. To maintain the desired consistency, adjustments to the water-cement ratio and the use of superplasticizers may be necessary (Chen et al., 2020).

Economic Considerations:

- **Cost Savings:**

Research indicates the potential for cost savings in concrete production when using recycled metallic filings. These savings can result from reduced expenses related to raw material acquisition and waste disposal (Yin et al., 2018).

- **Sustainable Construction Practices:**

The incorporation of recycled metallic filings aligns with the principles of sustainable construction. It demonstrates a commitment to responsible resource management, waste reduction, and reduced environmental impact, making it an attractive option for environmentally conscious projects (Tam et al., 2019).

- **Practical Applicability:**

- While research findings are promising, the practical applicability of using metallic filings in concrete is a key consideration. The development of guidelines and recommendations for industry professionals is crucial to facilitate the adoption of this sustainable practice (Wang et al., 2021).

2.3 HOW DOES RECYCLED METALLIC FILINGS AS PARTIAL REPLACEMENT OF FINE AGGREGATE IMPACT ON CONCRETE BASED ON LITERATURE REVIEWS?

Introduction: The construction industry is undergoing a transformative shift towards sustainable and environmentally responsible practices. as part of this evolution, researchers and engineers are exploring innovative materials and techniques that reduce the environmental footprint of concrete production. one such material that has gained attention is recycled metallic filings, often considered an industrial waste product. this essay delves into the multifaceted impact of incorporating recycled metallic filings into concrete, encompassing aspects of compressive strength, workability, durability, cost-efficiency, sustainability, and environmental impact.

Compressive Strength: The compressive strength of concrete is a critical parameter that determines its structural performance. the introduction of recycled metallic filings as a partial replacement for fine aggregate can influence this parameter. recycled metallic filings, characterized by their irregular shape and varying sizes, introduce complexities into the packing arrangement of particles within the concrete matrix. this irregularity, if not managed meticulously, can lead to a marginal reduction in compressive strength. however, the extent of this impact is contingent on factors such as the replacement ratio and the specific properties of the recycled metallic filings used. proper mix design, including adjustments in the water-cement ratio and the incorporation of mineral admixtures or chemical additives, can often mitigate any reduction in strength and, in certain cases, even enhance it.

Workability and Flow: Workability and flow are crucial for ensuring that concrete can be effectively placed and compacted in construction scenarios. the presence of recycled metallic filings can introduce challenges in this regard due to their coarser and less spherical nature compared to traditional fine aggregates. this inherent coarseness can potentially hinder workability. nonetheless, modern concrete technology provides solutions, chief among them being superplasticizers. these chemical additives, when judiciously employed, can render the concrete more workable and ensure adequate flow, thereby overcoming the workability challenges posed by recycled metallic filings.

Durability: The durability of concrete is paramount for its long-term performance and service life. recycled metallic filings hold the key to enhancing this critical aspect. iron, an inherent component of the filings, can function as a supplementary cementitious material. it participates in additional hydration reactions, leading to the formation of secondary cementitious phases that refine the microstructure of concrete. consequently, recycled metallic filings concrete exhibits heightened resistance to environmental stressors, including chloride ion intrusion, sulfate attack, and alkali-silica reaction. this translates into prolonged service life and reduced maintenance demands, substantiating the material's long-term durability.

Cost-Efficiency: The financial implications of adopting recycled metallic filings as a partial replacement for fine aggregate are noteworthy. while there may be initial costs associated with acquiring recycled metallic filings and, in some cases, additives to optimize mix designs, the economics of recycled metallic filings concrete often favor long-term benefits. the improved durability of structures constructed with recycled metallic filings concrete translates into reduced maintenance and repair expenditures over time. moreover, the sustainable nature of this material aligns with contemporary environmental regulations and global sustainability initiatives, potentially resulting in economic incentives or mitigation of environmental fees.

Sustainability: The essence of sustainability in construction hinges on prudent resource management. by reducing the demand for conventional fine aggregates, which are frequently sourced through energy-intensive extraction processes from finite natural deposits, recycled metallic filings offer a reprieve to these resources. recycled metallic filings, often generated as byproducts in various industrial processes, present an eco-conscious alternative. this not only curbs the depletion of natural resources but also ameliorates the carbon footprint associated with aggregate extraction, transportation, and processing. in essence, recycled metallic filings in concrete epitomize a sustainable choice that resonates with the ethos of responsible construction.

Environmental Impact: The integration of recycled metallic filings can wield a significant reduction in the environmental impact of concrete production. conventional fine aggregate extraction and its subsequent transportation are recognized as resource-intensive and environmentally burdensome procedures. They consume substantial amounts of energy and release copious greenhouse gas emissions. By pivoting towards recycled metallic filings, which are often acquired as industrial byproducts, the construction industry champions a reduction in its environmental footprint. This is not merely a shift in practice but a resounding response to global climate change mitigation efforts. The decreased energy consumption and emissions associated with recycled metallic filings concrete bolster its candidacy as an eco-sensitive construction solution.

Conclusion: In conclusion, the incorporation of recycled metallic filings as a partial replacement for fine aggregate in concrete is a nuanced journey of considerations and outcomes. While it introduces subtle shifts in compressive strength and workability, these nuances can be harnessed through adept mix design. The overarching advantages, spanning enhanced durability, cost-effectiveness, sustainability, and diminished environmental impact, place recycled metallic filings at the forefront of innovative construction practices. They not only present an alternative but also exemplify a commitment to a more sustainable and resilient future for the construction industry.

2.4 PHYSICAL AND CHEMICAL PROPERTIES OF MATERIALS USED

Table 2.1: Physical properties of Cement used (OPC Dangote Cement 42.5)

(BSI: Brussels, Belgium, 2011.)

PHYSICAL PROPERTIES OF CEMENT (OPC)	
PROPERTIES OF MATERIALS	**VALUE**
CONSISTENCY	25-35%
SETTING TIME	INITIAL SETTING: 30-45 MINUTES; FINAL SETTING: 300-400 MINUTES
COMPRESSIVE STRENGTH	3-DAY STRENGTH: ≥20 MPA; 7-DAY STRENGTH: ≥28 MPA; 28-DAY STRENGTH: ≥42.5 MPA
DENSITY	TYPICALLY, AROUND 3.15 G/CM³
COLOR	GRAYISH
CHEMICAL COMPOSITION	PRIMARILY COMPOSED OF CLINKER, GYPSUM, AND MINOR ADDITIVES
PARTICLE SIZE DISTRIBUTION	TYPICALLY, WITH SOME PARTICLES BELOW 45 MICRONS

Table 2.2: Chemical Properties of Cement (BSI: Brussels, Belgium, 2011)

CHEMICAL PROPERTIES OF CEMENT	
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

Table 2.3: Physical properties of RECYCLED METALLIC FILINGS (Wang et al., 2021)

PHYSICAL PROPERTIES OF RECYCLED METALLIC FILINGS	
PROPERTIES OF MATERIALS	**VALUE**
PARTICLE SIZE AND SHAPE	tiny, elongated, and irregularly shaped particles ranging from fine dust to larger flakes or shavings.
DENSITY	moderate to high density compared to many fine aggregates, influencing the overall density of concrete mixes.
MAGNETIC PROPERTIES	strongly magnetic due to their iron content, making them suitable for magnetic applications in construction.
COLOR	typically, dark gray or black due to their iron composition.
CHEMICAL STABILITY	generally stable but can rust or corrode when exposed to moisture and oxygen over time.

Table 2.4: Physical properties of Fine Aggregate (Ippei Maruyama, 2012)

PHYSICAL PROPERTIES OF FINE AGGREGATE	
PROPERTIES OF MATERIALS	**VALUE**
SPECIFIC GRAVITY	2.66
BULK DENSITY	1.52
MAXIMUM SIZE	4.75MM
MINIMUM SIZE	0.075MM
PARTICLE SIZE DISTRIBUTION	TYPICALLY, FROM 4.75 MM (NO. 4 SIEVE) PREDOMINANTLY RETAINED ON 0.075 MM (NO. 200 SIEVE)

Table 2.5: FINE AGGREGATE VS RECYCLED METALLIC FILINGS

(Ippei Maruyama, 2012)

CHARACTERISTICS	METALLIC FILINGS	FINE AGGREGATE (SAND)
Composition	Small metal shavings or filings (e.g., iron, steel, aluminum)	Small particles of natural or manufactured materials (e.g., sand, crushed stone, gravel)
Use	Metalworking, welding, magnetic devices	Construction, concrete, mortar, road base
Properties	Conductive, malleable, potentially magnetic	Nonmetallic, hardness, particle size distribution
Color and Appearance	Metallic Sheen, varies with metal type	Natural colors (e.g., beige, gray, brown)
Applications	Metal fabrication, electronics, magnetic tech	Construction materials, civil engineering
Load Bearing Capability	Limited	Provide Structural support
Electrical Conductivity	High	Typically, Low
Magnetic Properties	Present in some filings	Not magnetic
Cost	Cost varies depending on the type of filing material	Cost varies depending on the type and availability of fine aggregates

CHAPTER THREE

3.0 METHODOLOGY

This chapter presents the various tests, materials used and the procedures involved in making the various concrete cubes and beams which were used to ascertain the characteristic concrete properties of both the one made of natural fine aggregate and those made with replacements. The mix design for the concrete made with granite and recycled metallic filings, including the tests carried out and the procedure used in carrying out the test are all included in this chapter. the concrete cube samples were produced in accordance with BS1881. The experiment was performed in the structural laboratory of the civil engineering department of university of Benin. the tests carried out in this research project in include:

(i) Sieve Analysis Test

(ii) Slump Test

(iii)Compressive Test

For all tests, the fine aggregate was replaced with recycled metallic filings 0%, 5%, 10%, 15% and 20% respectively.

Table 3.1 showing the ratios of replacement

RATIOS OF THE MATERIALS USED FOR THE FINE AGGREGATE	
SAMPLE NAME	**RECYCLED METALLIC FILINGS (%)**
100% fine aggregate	0
95 % fine aggregate	5
90 % fine aggregate	10
85 % fine aggregate	15
80 % fine aggregate	20

3.1 MATERIALS

The following materials were used in producing the concrete cubes and beams in the laboratory.

1) Coarse Aggregate
2) Fine Aggregate
3) Cement
4) recycled metallic filings
5) Water
6) Oil

3.1.1 CEMENT

According to table 2.1 and table 2.2, the cement type used was Portland Limestone Cement of 42.5 grade (Dangote brand). This was gotten from a cement depot located by the Agen Junction, Oluku, Ovia North-East L.G.A of Edo State. The cement was carefully handled and stored by keeping it air tight and was only opened when a sample of it was needed. The cement was stored in a dry environment to prevent moisture absorption.

3.1.2 RECYCLED METALLIC FILINGS

Recycled metallic filings are small, elongated, and finely divided particles of iron. they are typically produced by shaving, grinding, or milling iron or iron alloys into tiny fragments. recycled metallic filings are characterized by their metallic luster and magnetic properties due to their high iron content. they are often used in various applications, including science experiments, educational demonstrations, and specialized construction projects where their magnetic or physical properties are advantageous.

3.1.3 FINE AGGREGATE

Natural river sand, conforming to ASTM C33 specifications was used. This was gotten from Edo state's Uselu-Lagos Road. A sieve study of the fine aggregate revealed that it belongs to zone II since it passed through a sieve of 4.75mm and was retained on a 600-meter sieve. Through careful handpicking and filtering, the fine aggregate was purified of all contaminants. In order to ensure that the fine aggregate's inherent moisture is decreased to a level that it cannot affect the test findings, it was air dried for 72 hours prior to casting. Well-graded river sand that is 4.75 mm thick was used as the fine aggregate. The sand was air drie d and sieved to remove any impurities before mixing

3.1.4 COARSE AGGREGATE

Regular aggregate, consisting of uncrushed blue granite with particle sizes between 10 and 20 mm, was used as the coarse aggregate. We are evaluating the relative density, fineness modulus, and water absorption capacity of coarse aggregate. Since aggregate normally accounts for between 70% and 80% of the volume of concrete, it significantly affects the properties of the substance.

The coarse aggregates used are gravel and crushed rock, which was gotten from quarry and its particle range was 10mm - 20mm. It is purchased from a local supplier along Lagos - Benin Express Road, Benin - City, Edo State. Analysis was carried out on the aggregate and their representative grain size distributed distribution obtained.

Table 3.2: Physical properties of Coarse Aggregate

PHYSICAL PROPERTIES OF COARSE AGGREGATE	
PROPERTIES OF MATERIALS	**VALUE**
SPECIFIC GRAVITY	2.65
BULK DENSITY	1.41
PARTICLE SIZE DISTRIBUTION	TYPICALLY, FROM 4.75 MM (NO. 4 SIEVE) TO 19.0 MM (3/4 INCH) OR LARGER
MAXIMUM SIZE	20MM
MINIMUM SIZE	10MM

3.1.5 WATER

Water is a constituent of concrete used for hydration purpose. The amount of water used for mixing and curing concrete depends on the durability criteria, intended strength and desired work ability. The water used for the mixing must be clean and free from oils, acids, sugar, organic material etc. The amount of water used in various mixes was based on the water /cement ratio in the mix design.

3.1.6 OIL/GREASE

GREASE was used in lubricating the concrete moulds (concrete cube cavities) for the concrete to be easily separated from it after it has solidified. It was also used in lubricating the cone during slump test for easy removal to prevent any damage to the fresh concrete specimen.

3.2 EXPERIMENTAL DESIGN

MACHINES AND EQUIPMENT USED DURING THE TESTS

The tools, equipment and machines used during this study include

1) Concrete mixer
2) Compression testing machine
3) Vibrating table
4) Weighing machine
5) Oven
6) Shovel
7) A set of sieves
8) Head pans
9) Buckets
10) Tamping rod
11) Measuring tape
12) Cone
13) Measuring cylinder
14) Hand trowel.
15) Concrete moulds
16) Head pan

3.3 SIEVE ANALYSIS

The Sieve analysis was carried to determine the particle Size distribution of the samples.

Apparatus

i. A set of British Standard sieve
ii. Weighing balance
iii. Cleaning brush
iv. Scoop
v. Pan

Procedure

1. The samples are air dried
2. Each of the sieves were weighed and recorded as W_1.
3. The Sieves were arranged according to specification decreasing order of size
4. The Sample (fine aggregate), about 3000g was Sieved through a stack of Sieves by handshaking in horizontal rotation for some minutes
5. Each of the sieve and its content was weighed and recorded as W_2
6. The weight of the soil retained on each sieve was obtained by subtracting W_1 from W_2
7. For the percentage retained in each sieve, weight on each sieve was divided by the original mass

The percentage passing was calculated by starting with 100% and subtracting the percentage retained on each sieve.

A graph of percentage passing against the sieve size was plotted

Percentage retained = mass retained/mas total x 100%

Percentage passing = (100 – percentage retained) x 100%

3.4 MIX PROPORTIONS

A total of five different concrete mixes were prepared:

1. control mix (0% recycled metallic filings replacement)
2. 5% recycled metallic filings replacement
3. 10% recycled metallic filings replacement
4. 15% recycled metallic filings replacement

the mix proportions were designed to maintain a constant water-cement ratio for all mixes to ensure a fair comparison. The specific mix design was based on the absolute volume method, conforming to ASTM C192.

3.5 MIX DESIGN

Mix design is a crucial process in concrete technology that involves determining the proportions of various ingredients to achieve the desired properties and performance of concrete. It aims to create a concrete mix that meets strength, durability, workability, and other specified requirements for a given construction project.

In order to evaluate the properties of recycled metallic filings in concrete, four combinations were tested.

The control mix was not made with recycled metallic filings. additionally,5%, 10%,15% and 20% of the fine aggregate was replaced with recycled metallic filings.

Table 3.3: Mix Design Showing Different Percentage Replacement of Fine Aggregate with RECYCLED METALLIC FILINGS

MIX DESIGN SHOWING DIFFERENT PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS						
Percentage Replacement by weight	**No. of cubes**	**Cement (kg)**	**Fine Aggregate (kg)**	**Coarse Aggregate (kg)**	**Water (liter)**	**RECYCLED METALLIC FILINGS (kg)**
For 0%	**9**	**3.06**	**4.635**	**12.465**	**1.53**	**0**
For 5%	**9**	**3.06**	**7.091**	**12.465**	**1.53**	**0.709**
For1 0%	**9**	**3.06**	**7.091**	**12.465**	**1.53**	**1.418**
For 15%	**9**	**3.06**	**7.091**	**12.465**	**1.53**	**2.127**

3.5.1 MIXING PROCEDURE

1. the required amount of cement, fine aggregates were dry-mixed for 2 minutes.
2. recycled metallic filings were then added to the mix and dry-mixed for an additional 2 minutes.
3. water was added gradually, and the mixture was wet-mixed for 5 minutes to achieve a homogeneous consistency.

3.6 SLUMP TEST

Concrete slump test is to determine the workability or consistency of concrete mix prepared in the laboratory.

Apparatus

a. Slump cone: In the form of the frustrum of a cone having height 30cm, bottom diameter 20cm and top diameter 10cm.

b. Base plate

c. Measuring tape

d. Tamping rod

PROCEDURES

1) The internal surface of the cone was cleaned and oil applied to it.
2) The cone was then placed on a smooth horizontal non-porous base plate.
3) The cone was then filled with already mixed fresh concrete in 3 approximately equal layers.
4) Tamping was done at each layer with 25 strokes.
5) The excess concrete was removed with trowel. The cone was raised immediately with the base supported.
6) The slump was measured using a measuring tape as the difference between the height of the cone and the height of concrete specimen.

3.7 COMPRESSIVE STRENGTH TEST

Compressive strength test is the capacity of a material or structure to withstand loads tending to effect size reduction of the concrete member or specimen.

Compressive strength tests were conducted on the cured specimens using compression testing machines. specimens were tested at various curing durations (e.g., 7, 21, and 28 days) to assess the strength development over time and evaluating the influence of recycled metallic filings on concrete's compressive strength.

Before delving into the intricacies of the compressive strength test, it is vital to understand the initial steps involved. Samples of concrete, often in the form of cubes are meticulously cast from the concrete mixtures under scrutiny. These samples are prepared with precision, adhering to standardized dimensions and procedures. The dimensions used was 100mm x 100mm x 100mm cubes.

EQUIPMENTS USED

i. Universal Testing Machine
ii. Weighing balance

PROCEDURE

1. The cubes were removed from the curing tank after, have attained their curing age
2. The cubes were then placed on a platform and allowed to dry for about an hour.
3. Weight of the concrete cubes are obtained using a weighing balance
4. The cubes were centrally aligned on the base plate of the Universal testing machine (UTM). The machine is started and readings is taken immediately the specimen fails
5. The load at failure is known as failure load

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

PRECAUTIONS

i. Protective hand gloves and safety shoes and overall were worn throughout the test.

ii. The Machine was switched off immediately after use.

iii. All the exposed parts of the equipment were kept lubricated.

iv. The guide rod attached to the machine was kept firmly to the base and top plate.

v. All the equipment were thoroughly cleaned before and after the test.

vi. Instructions were demanded from the laboratory technologists and technicians wherever necessary.

3.7.1 SAMPLE PREPARATION

Concrete specimens were prepared according to the mix design, ensuring uniformity and consistency in mixing and casting. Curing methods were employed to promote proper hydration and development of compressive strength. The samples were prepared in standard 100 mm x 100 mm x 100 mm cubic molds for compressive strength testing. Each mix was cast into nine cubes to ensure repeatability.

3.7.2 CURING

After casting, the specimens were covered with plastic sheets to prevent moisture loss and promote proper hydration and development of compressive strength. Each set of cubes were cured at room temperature for 7, 21, and 28 days.

1. **Durability Tests:** The durability of the recycled metallic filings concrete was assessed through water absorption tests following ASTM standards (C642). Water absorption test indicates the amount of water absorbed by the concrete specimen during the immersion period.

   The water absorption test provides important information about the permeability and porosity of concrete. A higher water absorption percentage indicates that the concrete has a more open and porous structure, which can impact its durability and resistance to environmental factors like freeze-thaw cycles and chemical attack.

   Low water absorption is generally desirable for concrete used in applications where durability and resistance to moisture are critical, such as in structural elements and concrete pavements. High water absorption may be acceptable for non-structural applications but should be carefully considered based on the intended use and environmental conditions.

3.8 DATA COLLECTION AND ANALYSIS

All data obtained from the experiments were recorded and analyzed statistically. The compressive strength results were compared between the different mixes to evaluate the effect of recycled metallic filings replacement on concrete strength. durability test results were also analyzed to assess the long-term performance of recycled metallic filings concrete.

graphical representations and mathematical models were employed for a comprehensive analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 INTRODUCTION

In this chapter, the findings from each test run during the course of this investigation are presented. Where appropriate, graphs and charts are also provided to illustrate how each of the percentage (%) replacement aggregates performed in comparison to the others.

The tests carried out include:

i. Slump Test
ii. Sieve Analysis Test
iii. Compressive Test

4.1 COMPRESSIVE STRENGTH TEST

The test on concrete for strength (compression test) was carried out on each cube cast (they were tested at days 7, 21 and 28).

Three (3) cubes were crushed for each of the percentage replacement on each crushing day and the average crushing value recorded. A total of 15 cubes were crushed every 7days. The test was carried out in accordance with the provision of BS 1881-116

In order to determine the compressive strength of concrete cubes, a universal compression testing machine with a 2000 KN capability was employed.

A pivotal aspect of the compressive strength test is the determination of the type of failure that occurs. Concrete typically fails through crushing, which is the anticipated outcome.

However, the test may sometimes reveal unexpected modes of failure, such as splitting or shear. Recording and analyzing the failure mode provides valuable insights into the concrete's behavior under stress.

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. The formula is straightforward:

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

Compressive Strength at 0% Replacement: $\frac{\textbf{water}}{\boldsymbol{cement}}$ **= 0.48**

Table 4.1: Table Showing Compressive strength of 0% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 7days

CUBE TEST					
COMPRESSIVE STRENGTH OF 0% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 7DAYS					
SPECIMEN	**WEIGHT (Kg)**	**AREA (mm^2)**	**FAILURE LOAD (KN)**	**COMPRESSIVE STRENGTH (N/ mm^2)**	**AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)**
Cube 1	**2.621**	**100 x100**	**214.88**	**21.488**	**19.919**
Cube 2	**2.545**	**100 x100**	**193.81**	**19.381**	
Cube 3	**2.488**	**100 x100**	**188.88**	**18.888**	

Table 4.2: Table Showing Compressive strength of 0% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 21days

CUBE TEST					
COMPRESSIVE STRENGTH OF 0% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 21DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.654	100 x100	299.08	29.908	29.565
Cube 2	2.768	100 x100	297.89	29.789	
Cube 3	2.702	100 x100	289.98	28.998	

Table 4.3: Table Showing Compressive strength of 0% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 28days

CUBE TEST					
COMPRESSIVE STRENGTH OF 0% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 28DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.426	100 x100	320.95	32.905	31.008
Cube 2	2.501	100 x100	315.15	31.515	
Cube 3	2.533	100 x100	310.05	31.005	

Table 4.4: Table Showing Compressive strength of 5% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 7days

CUBE TEST					
COMPRESSIVE STRENGTH OF 5% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 7DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.924	100 x100	200.73	20.073	17.026
Cube 2	2.830	100 x100	126.73	12.673	
Cube 3	2.771	100 x100	183.62	18.362	

Table 4.5: Table Showing Compressive strength of 5% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 21days

CUBE TEST					
COMPRESSIVE STRENGTH OF 5% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 21DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.705	100 x100	164.05	16.405	15.078
Cube 2	2.619	100 x100	120.45	12.045	
Cube 3	2.784	100 x100	167.84	16.784	

Table 4.6: Table Showing Compressive strength of 5% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 28days

CUBE TEST					
COMPRESSIVE STRENGTH OF 5% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 28DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.601	100 x100	222.95	22.295	22.134
Cube 2	2.650	100 x100	219.09	21.909	
Cube 3	2.588	100 x100	221.97	22.197	

Table 4.7: Table Showing Compressive strength of 10% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 7days

CUBE TEST					
COMPRESSIVE STRENGTH OF 10% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 7DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.474	100 x100	115.33	11.533	10.359
Cube 2	2.234	100 x100	100.78	10.078	
Cube 3	2.407	100 x100	94.65	9.465	

Table 4.8: Table Showing Compressive strength of 10% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 21days

CUBE TEST					
COMPRESSIVE STRENGTH OF 10% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 21DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.681	100 x100	121.58	12.158	11.454
Cube 2	2.864	100 x100	120.11	12.011	
Cube 3	2.807	100 x100	101.93	10.193	

Table 4.9: Table Showing Compressive strength of 10% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 28days

CUBE TEST					
COMPRESSIVE STRENGTH OF 10% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 28DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.720	100 x100	186.11	18.611	18.418
Cube 2	2.702	100 x100	181.01	18.101	
Cube 3	2.688	100 x100	185.43	18.543	

Table 4.10: Table Showing Compressive strength of 15% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 7days

CUBE TEST					
COMPRESSIVE STRENGTH OF 15% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 7DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.688	100 x100	205.64	20.564	18.564
Cube 2	2.657	100 x100	191.20	19.120	
Cube 3	2.656	100 x100	160.08	16.008	

Table 4.11: Table Showing Compressive strength of 15% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 21days

CUBE TEST					
COMPRESSIVE STRENGTH OF 15% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 21DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.604	100 x100	270.66	27.066	12.313
Cube 2	2.690	100 x100	34.94	3.494	
Cube 3	2.689	100 x100	63.79	6.379	

Table 4.12: Table Showing Compressive strength of 15% Percentage Replacement of Fine Aggregate with Recycled Metallic Filings for 28days

CUBE TEST					
COMPRESSIVE STRENGTH OF 15% PERCENTAGE REPLACEMENT OF FINE AGGREGATE WITH RECYCLED METALLIC FILINGS FOR 28DAYS					
SPECIMEN	WEIGHT (Kg)	AREA (mm^2)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/ mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/ mm^2)
Cube 1	2.450	100 x100	152.02	15.202	14.841
Cube 2	2.500	100 x100	144.24	14.424	
Cube 3	2.456	100 x100	148.97	14.897	

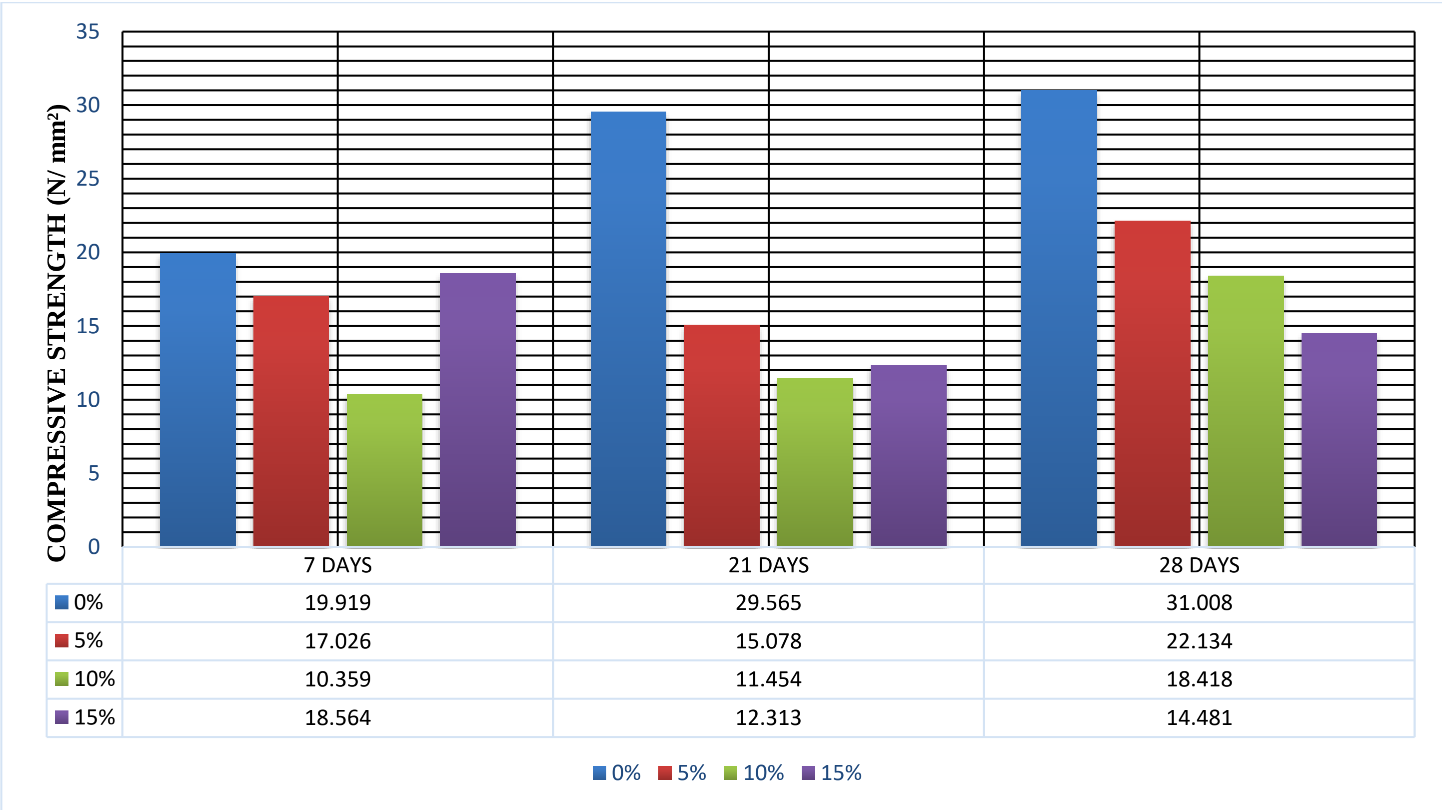

Figure 4.1: Average Compressive Strength for Various Proportion

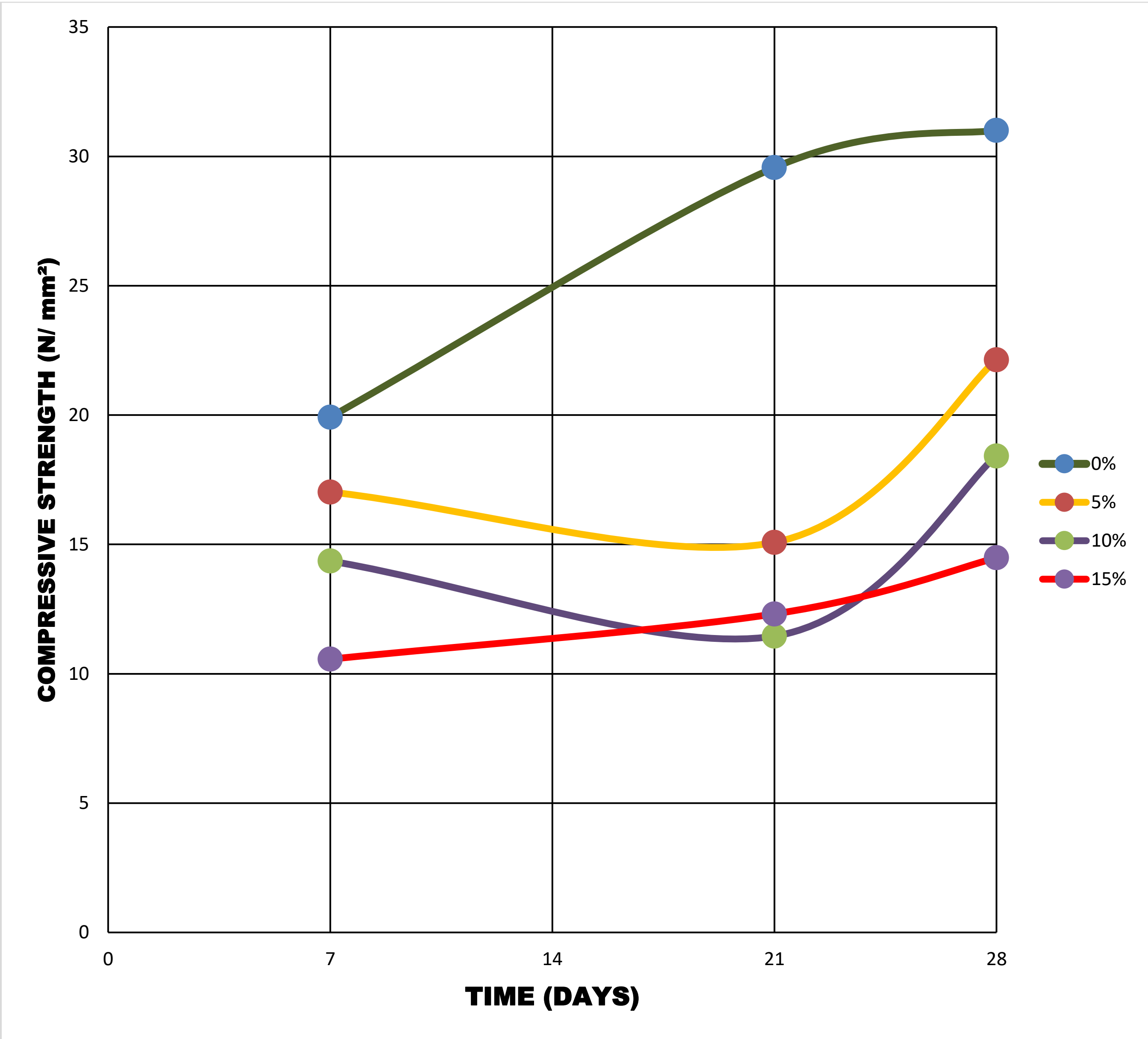

Figure 4.2: Average Compressive Strength for Various Proportion

4.2 SIEVE ANALYSIS

Table 4.13: Result from Sieve Analysis for Coarse aggregate

Total Mass of sand tested = 100.00g

Sieve Sizes	Percentage Passing (%)
19.04mm	98.30
12.00mm	63.10
10.00mm	16.95
4.75mm	0

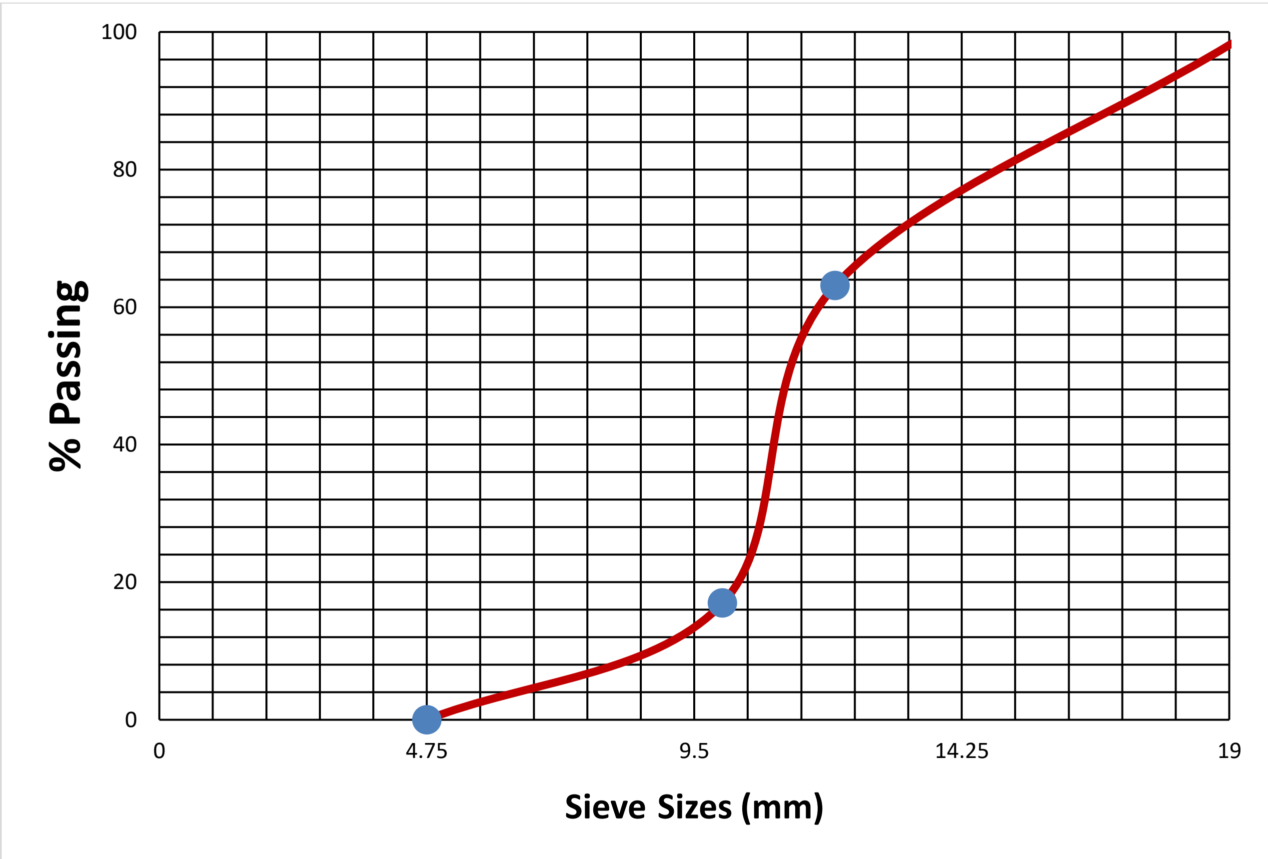

Figure 4.3: Particle Distribution for the Coarse Aggregate

Table 4.14: Result from Sieve Analysis for fine aggregate

Total Mass of sand tested = 100.00g

Sieve Sizes	Mass Retained (g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
2.36mm	0.59	1.26	0.11	100
2.00mm	0.20	0.15	2.71	99.41
1.18mm	2..78	6.627	9.408	99.21
600µm	27.92	31.66	41.068	96.42
425 µm	12.46	18.96	60.028	68.5
300 µm	19.77	22.92	82.948	56.04
212 µm	9.25	12.05	94.998	36.27
150 µm	4.91	0.69	95.688	27.02
75 µm	4.32	1.52	97.208	22.11
Pan	1.25	0.269	95.477	17.79

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

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

% loss < 0.5

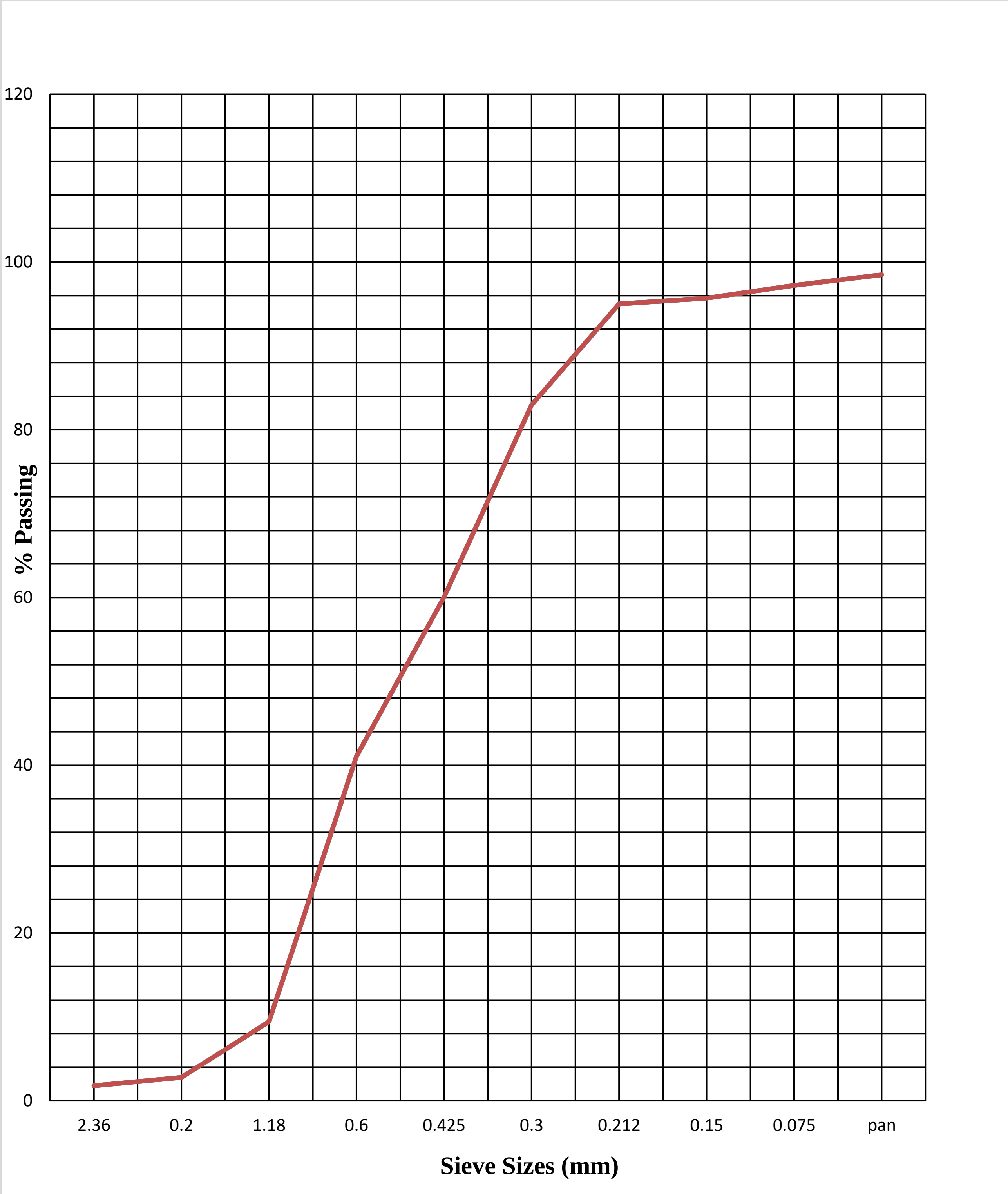

Fig 4.4 Showing Particle Distribution of the Natural Fine aggregate

Total Mass Tested = 100 g

4.2.1 RESULTS FROM SLUMP TEST

The results obtained from the Slump test on the various fresh concrete samples are shown on table 4.15

Table 4.15 Results from Slump test

SAMPLE NO	SLUMP (MM)
0% RECYCLED METALLIC FILINGS	20
5% RECYCLED METALLIC FILINGS	21
10% RECYCLED METALLIC FILINGS	23
15% RECYCLED METALLIC FILINGS	25

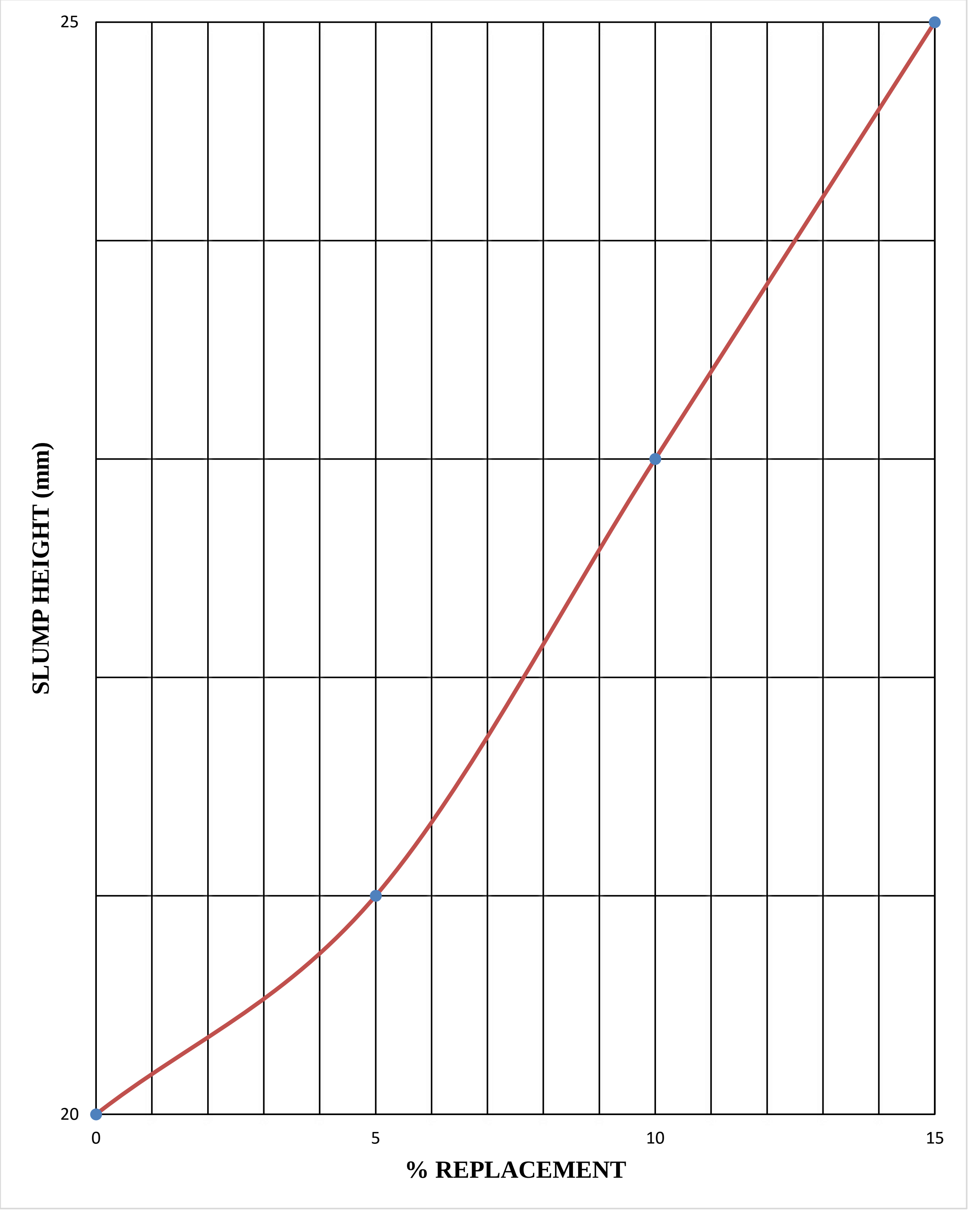

Fig 4.5 showing the variation of the slump with % increase in replacement

4.3 RESULT FROM COMPRESSION TEST

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

Table 4.16 Result for Compression Test for 100% Fine Aggregate (Grade 30)

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	2.621	2621	214.88	21.488	2551.33	19.919
	M_2	2.545	2545	193.81	19.381		
	M_3	2.488	2488	188.88	18.888		
21	M_1	2.654	2654	299.08	29.908	2708.00	29.565
	M_2	2.768	2768	297.89	29.789		
	M_3	2.702	2702	289.98	28.998		
28	M_1	2.426	2426	320.95	32.905	2486.67	31.008
	M_2	2.501	2501	315.15	31.515		
	M_3	2.533	2533	310.05	31.005		

Table 4.17 Result for compression test for 5% Recycled Metallic Filings (Grade 30)

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	2.924	2924	200.73	20.073	2841.67	17.026
	M_2	2.830	2830	126.73	12.673		
	M_{13}	2.771	2771	183.62	18.362		
21	M_1	2.705	2705	164.05	16.405	2702.67	15.078
	M_2	2.619	2619	120.45	12.045		
	M_3	2.784	2784	167.84	16.784		
28	M_1	2.601	2601	222.95	22.295	2613.00	22.134
	M_2	2.650	2650	219.09	21.909		
	M_3	2.588	2588	221.97	22.197		

Table 4.18 Result for compression test for 10% Recycled Metallic Filings (Grade 30)

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	2.474	2474	115.33	11.533	2371.67	10.359
	M_2	2.234	2234	100.78	10.078		
	M_3	2.407	2407	94.65	9.465		
21	M_1	2.681	2681	121.58	12.158	2784.00	11.454
	M_2	2.864	2864	120.11	12.011		
	M_3	2.807	2807	101.93	10.193		
28	M_1	2.720	2720	186.11	18.611	2703.33	18.418
	M_2	2.702	2702	181.01	18.101		
	M_3	2.688	2688	185.43	18.543		

Table 4.19 Result for compression test for 15% Recycled Metallic Filings (Grade 30)

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	2.688	2688	205.64	20.564	2667.00	18.564
	M_2	2.657	2657	191.20	19.120		
	M_3	2.656	2656	160.08	16.008		
21	M_1	2.604	2604	270.66	27.066	2661.00	12.313
	M_2	2.690	2690	34.94	3.494		
	M_3	2.689	2689	63.79	6.379		
28	M_1	2.450	2450	152.02	15.202	2468.67	14.841
	M_2	2.500	2500	144.24	14.424		
	M_3	2.456	2456	148.97	14.897		

4.4 DISCUSSION

Fig 4.5 shows that the slump of the fresh concrete decreased with increase in the replacement of the fine aggregate. This implies that the presence of recycled metallic filings 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 (C30).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

In conclusion, this research represents a significant step towards addressing the environmental challenges associated with concrete production while advancing sustainable construction practices. the findings provide valuable insights into the effects of partially replacing fine aggregate with recycled metallic filings in concrete.

The results demonstrate that while there is a reduction in compressive strength with higher recycled metallic filings content, it remains within acceptable ranges for various construction applications. this suggests that recycled metallic filings concrete can meet structural requirements, especially in scenarios where exceptionally high strength is not the primary consideration.

Workability challenges associated with recycled metallic filings concrete can be effectively addressed through mix design adjustments and the use of superplasticizers. this adaptability ensures that concrete remains practical and feasible for construction purposes.

One of the most promising aspects of this research is the enhanced durability of recycled metallic filings concrete. it exhibits resistance to environmental stressors, including freeze-thaw cycles, chemical exposure, and sulfate attacks. this durability advantage not only contributes to the long-term performance of structures but also reduces the need for maintenance and repair, ultimately lessening the environmental impact.

From an environmental perspective, the research underscores the potential for resource conservation. by reducing the demand for natural fine aggregates, recycled metallic filings concrete can help preserve natural reserves and ecosystems. additionally, the reduction in the carbon footprint associated with concrete production aligns with global efforts to combat climate change. in practical terms, the research findings offer a pathway for the construction industry to adopt more sustainable practices. engineers, architects, and builders can consider the use of recycled metallic filings concrete in projects where environmental responsibility is a priority. policymakers and regulators can leverage this research to develop guidelines and incentives that promote the adoption of alternative materials in construction.

Overall, the study on the effects of the partial replacement of fine aggregate with recycled metallic filings in concrete represents a pivotal contribution to the ongoing discourse on sustainable construction materials. it exemplifies the potential for innovation within the construction industry, where sustainability and structural integrity can coexist, paving the way for a more environmentally conscious and resilient future.

5.1 RECOMMENDATIONS

Based on the findings of this project work, several recommendations can be made to improve the effect of partial replacement of fine aggregate with recycled metallic filings in concrete production:

1. **Optimized Mix Design:** Further research should focus on fine-tuning mix designs to strike a balance between sustainability and practicality. this includes investigating additional additives, admixtures, and mix proportions that can enhance workability while maintaining the desired recycled metallic filings content.

2. **Standardization:** to facilitate the broader adoption of recycled metallic filings concrete, the development of standardized testing methods and guidelines is essential. collaboration among industry stakeholders, researchers, and regulatory bodies should be encouraged to establish consistent and reliable protocols.

3. **Real-World Applications:** beyond laboratory experiments, it is crucial to assess the performance of recycled metallic filings concrete in actual construction projects. Collaborations with builders and developers for pilot projects can provide invaluable insights into the material's feasibility, structural integrity, and long-term durability.

4. **Environmental Assessments:** Further research should delve into comprehensive life cycle assessments (LCAs) to quantify the environmental benefits of recycled metallic filings concrete comprehensively. LCAs can provide a holistic view of the material's sustainability, considering factors such as energy consumption, emissions, and resource conservation.

5. **Educational Initiatives:** Academic institutions, industry associations, and training programs should incorporate knowledge about alternative construction materials, including recycled metallic filings concrete, into their curricula. Educating future generations of engineers and construction professionals on sustainable practices is crucial.

6. **Policy Support:** Policymakers and regulators can play a pivotal role in advancing sustainable construction practices. Incentives, tax credits, or regulatory frameworks that promote the use of alternative materials in construction should be explored.

7. **Long-Term Monitoring:** Conducting long-term monitoring of structures built with recycled metallic filings concrete is essential to assess its performance over time. this data can provide valuable insights into the material's durability and maintenance requirements.

5.2 LIMITATIONS

This project work is not without its limitations. Some of the limitations include:

1. Recycled metallic filings are typically coarser and less spherical than traditional fine aggregates, which can make concrete mixes less workable.

2. The irregular shape and size of recycled metallic filings can lead to variability in concrete compressive strength.

3. Recycled metallic filings have a potential for corrosion over time, which can compromise the structural integrity of the concrete.

4. The study did not consider the long-term durability and performance of concrete containing recycled metallic filings rather the short-term performance.

5. Ensuring the consistent quality and availability of recycled metallic filings from reliable sources can be challenging.

5.3 POSSIBLE SOLUTIONS TO LIMITATIONS

To address these limitations, the following solutions can be considered:

1. The use of superplasticizers and water-reducing admixtures can improve workability. Proper mix design adjustments, such as optimizing the water-cement ratio, are essential to overcome workability issues.

2. Rigorous quality control and mix design optimization are crucial to maintain consistent strength. Adjustments in the proportion of recycled metallic filings and other materials can help achieve the desired strength.

3. The use of corrosion-resistant coatings on recycled metallic filings or the addition of corrosion inhibitors in the concrete mix can mitigate this risk. Proper curing and sealing of the concrete can also help prevent moisture ingress.
4. Conducting comprehensive durability studies and field trials can provide valuable insights into the long-term behavior of recycled metallic filings concrete. Monitoring structures over extended periods can help assess performance.

In summary, it's crucial for construction professionals to carefully assess these limitations and implement appropriate solutions when considering the use of recycled metallic filings in concrete. With proper planning, mix design optimization, and quality control measures, many of these limitations can be effectively addressed, making recycled metallic filings a viable and sustainable option in construction projects.

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APPENDICES

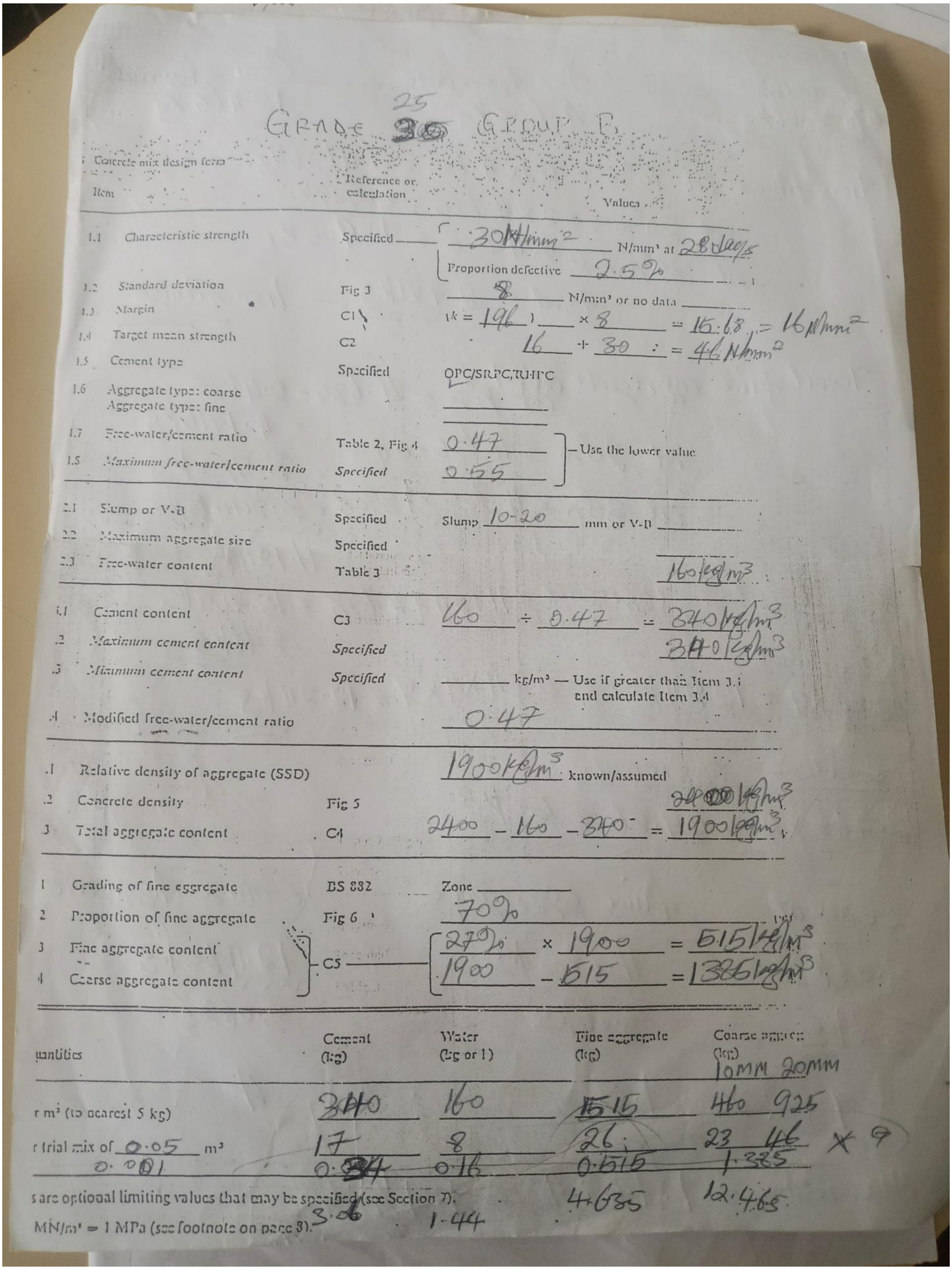
Plate1: concrete slump

Plate2: universal compressive machine

Plate3: crushing cubes

Plate4: crushing cubes

Plate5: crushing cubes



GRADE 25 GROUP B

Concrete mix design form

Item		Reference or calculation	Values
1.1	Characteristic strength	Specified	30N/mm² N/mm² at 28 days; Proportion defective 2.5%
1.2	Standard deviation	Fig 3	8 N/mm² or no data
1.3	Margin	C1	k = 196 × 8 = 15.68 = 16 N/mm²
1.4	Target mean strength	C2	16 + 30 = 46 N/mm²
1.5	Cement type	Specified	OPC/SRPC/RHPC
1.6	Aggregate type: coarse Aggregate type: fine		
1.7	Free-water/cement ratio	Table 2, Fig 4	0.47 — Use the lower value
1.8	*Maximum free-water/cement ratio*	*Specified*	0.55
2.1	Slump or V-B	Specified	Slump 10-20 mm or V-B
2.2	Maximum aggregate size	Specified	
2.3	Free-water content	Table 3	160 kg/m³
3.1	Cement content	C3	160 ÷ 0.47 = 340 kg/m³
3.2	*Maximum cement content*	*Specified*	340 kg/m³
3.3	*Minimum cement content*	*Specified*	kg/m³ — Use if greater than Item 3.1 and calculate Item 3.4
3.4	Modified free-water/cement ratio		0.47
4.1	Relative density of aggregate (SSD)		1900 kg/m³ known/assumed
4.2	Concrete density	Fig 5	2400 kg/m³
4.3	Total aggregate content	C4	2400 − 160 − 340 = 1900 kg/m³
5.1	Grading of fine aggregate	BS 882	Zone
5.2	Proportion of fine aggregate	Fig 6	70%
5.3	Fine aggregate content	C5	27% × 1900 = 515 kg/m³
5.4	Coarse aggregate content	C5	1900 − 515 = 1386 kg/m³

Quantities	Cement (kg)	Water (kg or l)	Fine aggregate (kg)	Coarse aggregate (kg) 10MM	20MM
per m³ (to nearest 5 kg)	340	160	515	460	925
per trial mix of 0.05 m³	17	8	26	23	46
0.001	0.34	0.16	0.515	1.385	
	3.06	1.44	4.635	12.465	

× 9

Items in italics are optional limiting values that may be specified (see Section 7).

1 N/mm² = 1 MPa (see footnote on page 3).

Plate5:Mix Design Chart