DECLARATION

BYAMUNGU Alain declare that this research entitled **"Feasibility study on partial replacement of fine aggregates by recycled plastic waste in concrete"** presented in this dissertation is my own contribution to the best of my knowledge. The same work has never been submitted to any other university or institution. I, therefore, declare that this work is my own for the partial fulfilment of the award of advanced diploma in Civil Engineering at ULK POLYTECHNIC INSTITUTE

BYAMUNGU Alain (202150393)

Date………………………….

Signature……………………..

CERTIFICATION

This is to clarify that this final project report entitled **“Feasibility study on partial replacement of fine aggregates by recycled plastic waste in concrete”** submitted to the institution (ULK Polytechnic institute), is the work of **BYAMUNGU Alain.** The project was carried out under my supervision and to the best of my knowledge the project has not in any part been submitted in any other academic institution.

Eng. MUKESHIMANA Annoncée Eng. Bonaventure NKIRANUYE

Supervisor Head of civil engineering department

Date……………………………….. Date………………………………..

DEDICATION

I dedicate this dissertation:

To the almighty GOD who helped me from the beginning

To my parents,

To my brothers and sisters,

To my family,

To my friends,

To my classmates and colleagues within the campus.

ACKNOWLEDGEMENT

I firstly thank the almighty God who has guided me through the whole life and in period of my studies, especially in this final year project.

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I also thank everyone who granted any kind of support for achievement of this work

God bless you all!

ABSTRACT

Concrete is the most extensively used construction material in the world and is the second only to water as the most heavily consumed substance, with about six billion tons produced every year. It has emerged as the dominant construction material for the infrastructure needs of the 21st century. Concrete is a composite material that consists essential of a binding medium, such as a mixture of Portland cement and water, within which are embedded particles or fragment of aggregate, usually a combination of fine and coarse aggregates. Plastics are a vast group of synthetic or semi-synthetic materials that are often made of polymers. Because of their plasticity, plastics can be moulded, extruded, and pressed into solid objects of different sizes. Its extensive use is due to its flexibility, as well as a number of other properties such as light weight, durability, and low manufacturing costs. The high use of plastics has resulted in an increase in solid waste, with domestic waste accounting for a significant portion of it. Since this waste is not biodegradable and takes up a lot of space, it is considered a serious environmental problem. To overcome these adverse effects, recycling plastic waste and using it in concrete can be an effective way to protect the environment. In this study, an attempt was made to experimentally evaluate the mechanical properties of concrete with recycled HDPE plastic wastes. The control mix was made and the other mix containing 8.8% of plastic waste in order to compare their characteristics, it was observed that the workability of partial replacement mix has decreased, the compressive strength too has decreased by 5.7%, and even the water absorption percentage decreased by 0.1 % compared to the concrete with 0% plastic wastes. The maximum compressive strength of a control mix after 28 days of curing was 29.7 MPa while the other mix with 8.8% of plastic wastes was 28 MPa. The incorporating of plastic waste can slightly reduce compressive strength due to its lower bonding capacity in the mix but this substitution helps reduce plastic pollution.

Keywords: concrete, recycle plastic wastes

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LIST OF ABREVIATIONS

ASTM: American Standard of Testing Materials

OPC: Ordinary Portland cement

PET: Polyethylene Terephthalate

HDPE: High-density polyethylene

LDPE: Low-density polyethylene

PVC: Polyvinyl chloride

PP: Polypropylene

PS: Polystyrene

ABS: Acrylonitrile Butadiene

Mpa: Mega pascal

N: Newton

N/mm2: Newton per millimetre square

KN: Kilo newton

CM: control mix

PR: Partial replacement

CHAPTER ONE: General Introduction

1.0 introduction

Nowadays, Environmental concern towards plastic wastes rises because of its low degradability And creating problems like chunking sewer lines, drainages, waterways, landfills, without forgetting many other health issues. The best approach is recycling and reuses of plastic wastes. There is increase in production of plastic day by Day but very few is recycled. On the other hand, there are hugely demand of concrete in construction industry and that why we need to think about the utilization of recycled plastic waste in the production of sustainable concrete by replacing partially some amount of fine aggregates with plastic waste.

Urbanisation and the evolution of people's lifestyles have a significant impact on the quality of waste that is generated and dumped each year. Products are made and then discarded resulting in waste. Most of these wastes are disposed at landfills and this is powered by the inefficiency of non-specific locations designed only for plastic wastes. The use of land space may hinder waste management which leads to disposition of those wastes directly or indirectly in the marine environment.

The construction industry is continuously seeking sustainable alternatives to traditional building materials due to increasing of environmental concerns and the need of more cost-effective solutions. One promising innovation is the use of plastic wastes as partial replacement of fine aggregates in concrete. This approach not only addresses the growing issue of plastic waste but also offers a range of benefits including economic savings, improved workability and reduced environmental impact.

1.1 Background of the Study

The growing amount of plastic waste is a significant environmental issue. Plastics are non-biodegradable and can persist in the environment for hundreds of years leading to land, water and air pollution. These wastes occupies a considerable amount of space in landfills and marine. Finding alternative uses for this waste can help reduce the burden on mentioned sites.

Using plastic wastes in construction can reduce cost, traditional construction materials like sand and natural aggregates are becoming increasingly expensive due to their depleting source which means by substituting plastic wastes for natural aggregates, the demand for these natural resources can be decreased leading to their conservation.

Research has shown that certain types of plastic waste can enhance the properties of concrete. For instance, plastic aggregates can improve the workability, reduce the density and offer other better thermal insulation properties compared to conventional aggregates. Studies indicate that replacing fine aggregates with plastic wastes (typically from 10% up to 20% by volume) can result in concrete with adequate compressive and tensile strength for various applications. Higher replacement levels might require modifications in the mix design to maintain structural integrity.

1.1 Problem Statement

1.2.2 Environmental concern

Plastic are durable and degrade very slowly nearer to impossible, the chemical bonds that make plastic so durable make them equally resistant to Natural processes of degradation. Since 1950s one billion tons of plastic have been discarded and may persist for hundreds or even thousands of years. Serious environmental threats from plastic include the increasing presence of micro plastics in the Marine food chain along with many other highly toxic chemical pollutants that plastic attracts and concentrate, and larger fragmented pieces of plastic called hurdles. In 960s the letter was observed in the guts of seabirds and since then have been Found increase in concentration. In 2009 it was estimated that 10% of modern wastes was plastic although estimates vary According to region meanwhile, 50-80% of debris in marine areas are plastic.

1.2.1.1 Environmental concern in our East African region

In our region plastic wastes are severely visible clogging the drainage systems contributing to flooding and littering landscapes.

Marine and terrestrial wildlife often ingest or become strangled in plastic waste. This can lead to injury, death and disruption of natural behaviours. Species like birds, fish and marine mammals are particularly vulnerable.

The lack of sufficient infrastructures for waste collection, recycling and disposal leads to widespread dumping of plastic waste in open areas and water bodies, additionally the burning of plastic wastes, a common disposal method, releases toxic fumes that can cause respiratory issues and other related health problems.

1.2.2 Climate change

The effect of plastics on global warming are mixed, plastics are made from petroleum. If the plastic is incinerated, it increases carbon emissions and if it is placed in a landfill its becomes a carbon sink. Although biodegradable plastics have caused Methane emissions due to the lightness of plastic versus glass or metal, plastic may reduce energy consumption. For example, in packaging beverages in PET plastic rather than glass or metal is estimated to save 52% in transportation energy.

1.3 Objectives

1.3.1 General objective

The general objective is to conduct a feasibility study on partial replacement of fine aggregates by recycled plastic wastes in concrete.

1.3.2 Specific objectives

- To select materials suitable for this study
- To determine the partial replacement percentage of fine aggregates
- To conduct the slump test on each concrete mix
- To test the water absorption percentage on each sample
- To identify the compressive strength test on concrete made with plastic as partial replacement of fine aggregates

1.4 Hypotheses

Is it possible to change a plastic waste from a scrap to a useful building material?

How, when and which processes could it take to recycle a plastic waste to a building material?

What differ existing material properties from recycled plastic wastes?

Are those materials durable like the others, how and why?

Can all types of plastics be recycled and be used in a construction industry?

1.5 Scope

This project will focus on types of plastics Identifying different types of plastic wastes (e.g., PET, HDPE, PVC) and their properties to relate with those of existing building materials, evacuating mechanical properties such as strength, durability, thermal insulation, and resistance to environmental factors, Investigating methods for collecting, sorting, and processing plastic wastes into building materials and study on application of plastic bottles in various building components such as bricks.

1.6 Significance of the Study

It Is expected that the findings of this project will cover way for the authorities in charge of construction and environmental management and conservation on how to reduce the plastic wastes to the maximum rate, what, how and where to use those wastes especially in building. It will therefore serve as a reference material for future researchers in this area and far.

1.7 Organisation of the project

This project will be structured into five chapters. Chapter one will deal with introduction, background of the Study, problem Statement, hypotheses, and objectives of the study, scope and the significance of the Study. Chapter two will consist of the literature review which will comprise conceptual definitions, theoretical and practical reviews with ideas from authors/experts and related studies. Chapter three will contain research methodology which comprise with research design, Study area, research population, sampling design and data collection method. Chapter four will highlights the presentation and interpretation of the data as well as discussion of the findings. Chapter five will contain the summary of the study, conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This literature review attempts to discuss the various literature related on the negative impact of plastic wastes on our planet and how to minimize at higher rate those impact by recycling them into useful materials needed in our Construction industry. However this project also attempt to fill some of those gaps left by other researchers so that the write up can contribute to a new body knowledge on how to treat plastic wastes in our community from scrap up to building materials. Through this review literature is re-packaged and analysed as a way of bringing new insights into the issues studied.

Plastic is commonly used material with huge social benefits, with the development of the world Economy the output of garbage around the world Is also increasing rapidly especially the use of plastic product is becoming more and more widespread without forgetting that disposable plastics are commonly uses in people's lives. Disposable plastic products have brought convenience to People's production and life, but due to difficult degradation of plastic products "white pollution" has become more and more serious. The large amount of disposable Plastic products and the low recycling rate are causing a lot of pollution to the soil and the marine environment. The world is facing an environmental crisis Caused by plastic wastes, currently "Limiting plastic" has become a global consensus, and many countries and regions have launched actions to limit plastic and ban plastic.

Based on particle size, plastics are classified as:

- Nanoplastics: particle size<0.0001 mm
- Small microplastics: particle size 0.00001–1 mm
- Large microplastics: particle size 1–4.75 mm
- Mesoplastics: particle size 4.76–200 mm
- Macroplastics: particle size>200 mm

2.1 Negative impact of plastic wastes on our planet

2.1.1 Soil pollution

In agriculture industry, plastic waste presents a seriously and frequently overlooked challenge with far- reaching impacts on both food production and safety. In recent years the issues of plastic waste has gained prominence due to its innate inability to biodegrade, resulting in widespread environmental problems. The build-up of plastic waste in agricultural areas can have detrimental effects on biodiversity, soil health and ecosystem function.

Plastic wastes can pollute the soil in agricultural areas, which will prevent plants from properly absorbing nutrients and thereby impede their growth. Also, the presence of plastic waste can abstract irrigation systems, potentially causing crop losses and water stagnation. In addition, toxic substances that are released by plastic into the environment could threaten human health if they are taken up by plants or eventually make their way into the food chain.

The improper disposal of plastic waste, such as bags, bottles or packaging materials has a number of detrimental effects on agriculture. It may result in soil pollution which could have an impact on agricultural output. Plastic accumulate in the soil because they take very long time to normally break down plastic debris can impede plant growth and impair how well they absorb nutrients.

Micro plastics can be absorbed by plants and build up in their tissues when they are present in the soil. This could result in the introduction of micro plastic into the food chain, which would have an effect on both crop yield and food safety. Additionally, a build- up of plastic debris can prevent the soil from properly draining water, which can cause waterlogging and reduce oxygen supply to plant roots, this may have a detrimental effect on the development of the crop’s roots and total farm output.

2.1.2 Marine pollution

The ocean is perhaps the most vulnerable environmental to plastic waste. Once plastic enters the sea, it has no boundaries because waves and storms can carry plastics to even the furthest reaches of the ocean, where they accumulate into large gyres on the High seas or become embedded in shorelines and delicate coastal ecosystems “They’ve even been found on uninhabited islands”. After some months or years at sea, plastic breaks down into smaller and smaller pieces, battered by waves and storms, eventually to sizes smaller than grain of sand. Thus makes retrieving plastic from the ocean extremely difficult almost impossible.

It is estimated that marine plastic are contributing to death of more than 100,000 marine mammals every year, there's now so much rubbish in our seas that it's clumping together to form a vast floating garbage patches all over the world. Take the Great Pacific Garbage Patch (GPGP) for example.

Most of plastic wastes flows into the lake from our rivers and also they enter the sea from the sewage system. The biggest cause of damage to wildlife is physically wounds or entrapment from plastic waste. Fish and marine birds becoming entangled in plastic packaging from things like plastic bags and plastic drink rings. This can cause painful wounds, strangulation or even drowning. Birds, mammals, and reptiles that live in the sea but still need air to breathe can become entangled that they cannot surface for oxygen, and they drown.

The other major danger of plastic in our rivers And lakes is that it's often mistaken for food and eaten by marine life. These unsuspecting creatures consume the plastic, which can choke them, cause eternal injuries or slowly starve them to death.

Plastic has already entered the food chain. Animals carry micro plastics in their bodies, when they are themselves eaten those micro plastics are also ingested. This process is called 'trophic transfer' of micro plastics. Since one animal eats another, micro plastics can move through the food chain. The main question is what happens to the toxins and chemicals that are associated with those plastics when they reach in human body after consuming contaminated fish.

It was estimated that about 8 million of metric tons of plastics enters the ocean every year. The total amount of plastic currently in the oceans is much harder to quantity precisely, but it's believed to be in the range of hundreds of millions of metric tons. They contribute to long lasting pollution as chemicals in plastics can leach out into the water.

2.1.3 Air pollution and climate change

Plastics are threatening the ability of the global community to keep global temperature rise below 1.5^{0}C, as the greenhouse gases (GHG) are emitted throughout the plastic life cycle. Indeed, extraction, refining and manufacture of plastics are all carbon intensive activities. In 2015, CO_2 and other GHGs a emissions from plastics production reached 1.96 Gt of $C0_{2e}$. At the disposal stage incineration of plastic wastes releases significant GHG into the atmosphere alongside toxic pollutants. Other disposal methods including recycling also comes with their share of GHG emissions.

Air and plastic pollution are interlinked in multiple ways. Burning plastic waste is common. So Almost 40% of plastic waste globally is burned, releasing toxins in the air. This leads to increased risk of cardiovascular diseases and respiratory ailments and can also damage the nervous system. Furthermore, greenhouse gas and other pollutants are released during production of plastic which worsens air quality and can drive climate change and inheritance environmental concerns.

Plastic is derived from fossil fuels, including natural gas and crude oil, and contain chemicals that are known endocrine disruptors and threaten human health. Plastic does not decompose instead it breaks up into smaller pieces called microplastics. These microplastics are particularly everywhere on earth and pose a deadly problem for wildlife. If too much microplastic accumulates in the animal, it can cause punctured organs or intestinal blockages. Human exposure to plastic with these chemicals may cause hormonal imbalances, reproductive problems and even cancer.

Plastic contributes to air pollution across its life cycle, from production to disposal. Through reduction in plastic consumption and effective and efficient waste management, we can create pathways to cleaner air and better health.

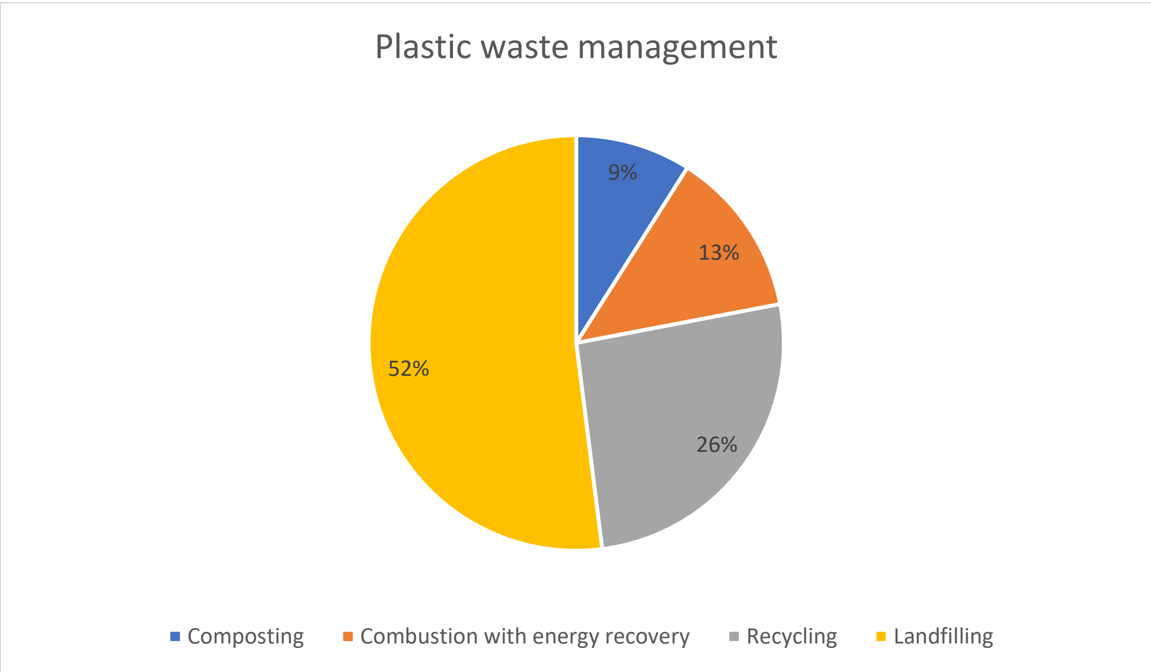

Figure 2.1: Scenario of plastic waste management

2.2 Types of plastics and their properties

Polyethylene Terephthalate (PET and PETE): is a strong, lightweight and transparent plastic. It has good resistance to moisture, solvents impacts.

High-density polyethylene (HDPE): is known for its high strength ratio, making it tough and resistant to impacts of chemical. It is also relatively lightweight and has good UV resistance.

Low-density polyethylene (LDPE): is softer, more flexible plastic. It has good resistance to acids, bases and most chemicals.

Polyvinyl chloride (PVC): Is a versatile plastic available in rigid and flexible forms. It is durable and resistant to chemicals and weathering.

Polypropylene (PP): Is a tough, rigid plastic with high melting point. It is resistant to fatigue. Chemicals and solvents.

Polystyrene (PS): This can be either a hard, solid plastic or a foam material. It has good clarity and rigidity in its solid foam and excellent insulation properties its foam form.

2.3 Application in building materials

Several types of plastic wastes exists, and the most common ones in waste streams are polyethylene and Polyethylene terephthalate (PET). As recycling of PW has been found to be effective, different ways to recycle these wastes have been extensively explored by the packaging industry, however, its uses in the construction industry is less common.

Plastics used in the construction industry come in various types, each with specific properties and recycling potential, I have tried to focus on the main types and their recycling applications

Polystyrene ((PS): Used in insulation materials such as expanded polystyrene EPS recycled PS is used in producing insulation boards, lightweight concrete and decorative mouldings.

Polyethylene Terephthalate ((PET): Often used in the form of polyester for fabrics and insulation. Recycled PET can be used in producing insulation materials and construction fibbers.

Acrylonitrile Butadiene (ABS): Used in piping, fittings and panels. Recycled ABS is used in new construction components and piping systems.

Polypropylene (PP): is used in various plastic products and can be processed into fine particles to replace a portion of sand in concrete and these particles can improve the concrete's durability and resistance to cracking due to their flexibility and toughness.

Polyvinyl Chloride (PVC): Recycled PVC often sources from construction waste like pipes and window frames can be ground into fine particles and used in concrete mixes and they can improve the fire resistance of concrete and reduce its overall environmental impact by recycling waste materials.

Polystyrene (PS): Expanded polystyrene (EPS) beads, typically used in packaging, can be mixed into concrete as a lightweight aggregates and can significantly reduce the weight of concrete, making it useful for lightweight construction applications and enhancing thermal insulation properties.

Polyethylene Terephthalate (PET): bottle the most commonly used plastic bottles in the construction projects, they are typically filled with sand, earth or other materials and used as building blocks in walls and bottles are durable, lightweight and widely available. They provide good thermal and acoustic insulation, reduce waste in landfills and offer a cost effective building solution. Additional, they can enhance the aesthetic appeal of structures with creative designs.

Polyethylene (PE): This includes high-density polyethylene (HDPE) and low density polyethylene (LDPE). PE used for pipes, insulation and vapour barriers. Recycled PE can be used for products like piping, plastic lumber and insulation materials.

Polypropylene (PP): Commonly found in piping systems, fittings and plastic parts. Recycled PP is often used in manufacturing construction products like plastic composite lumber and roofing membranes.

2.3.1 Recycling probability

The figure below represents the recyclability levels of different plastics for construction application. Basically, recyclability depends on different factors (i.e., cost of processing, availability, Collection procedure). In most cases, the plastic which recyclability level is easier have high levels of application and the plastic which recyclability is difficult have low levels of application As shown in the Figure below. From this figure it can be said that PET, HDEP, PP and LDEP could be recycled easily but recyclability of PVC and PS is difficult. Polystyrene (PS) has a high level of application despite their recyclability is very difficult. The reason for that may be related to the wide availability, low cost of production, and PS is mostly used plastic in term of packaging of different products.

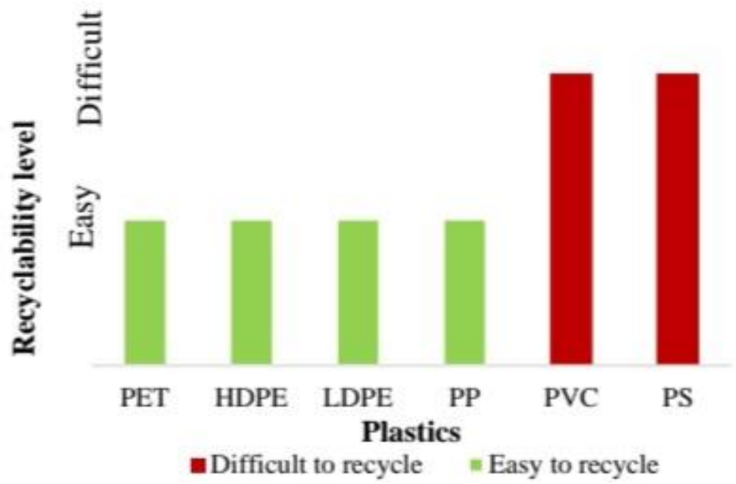

Figure 2.2: Recyclability level

2.4 Existing researches on plastic re use

Pooja.P et al (2019) collected milk pouches, Polyethylene bags, water bottles and shredded into 4mm-5mm. “The mixed plastic waste used was 15%, 20%, 30% replacement of fine aggregates in 0.45 w/c Ratio mix”. The compressive strength results for 15%, 20% and 30% were 20.57Mpa, 18Mpa and 15Mpa respectively. So he suggested to use this on temporary structures and less Load taking structures.

Menthol Kumar and Baskar (2015) the compressive strength of concrete cubes with recycled plastic waste was studied. It was observed the decrease of compressive strength with the increase of plastic waste percentage.

In the study carried out by Manaktar and Deshmukh (2015) it was observed that for concrete with compressive strengths equals to 20Mpa and 25Mpa with a percentage of up to 20% of coarse aggregates by plastic waste, there was a reduction in the compressive strength of concretes with plastic wastes percentage greater than 10%

Many architects around the world have also started using plastic as a way to build Low income and sustainable informal settlements in developing countries. A German National Andreas Froese invented the technique which involves the use of disposable PET bottles, debris and earth raw materials for construction. PET bottles are filled with sand Or soil or landfill dirt are mud and are used as bricks to construct houses. The technology has been adopted in different countries, including Nigeria, South Africa, Philippines and India. Thanks to this technique more than 300,000 PET bottles have been reused in More than 50 construction projects in Honduras, Columbia and Bolivia (Muyen, Barna & Hoque, 2016).

In some reports, PET derived from drinking water bottles was used as a replacement of sand in concrete formation. Different volumetric percentages of sand such as 2%, 5%, 10%, 15%, 20%, 30%, 50%, 70% and 100% were substituted by the same volumetric percentage of recycled PET aggregates. When the volume of aggregates was between o and 30%, the bulk density remained small. However, as the volume approaches 50%, the bulk density decreased and showed a minimum value of 1000 kg/m^3. In addition, by increasing the amount of aggregates from 0 to 50%, thee compressive power reduced by 15.7% as compared to the reference mortar. However, compressive strength greater than 3.5Mpa was observed when the volume of sand was fully replaced by PET. Up to a replacement stage of 50%m, high compactness was found. Beyond 50% volume the arrangement seems to be more spacious/broad (Marzouk Et al. 2997)

2.5 Technical challenges on using plastic wastes in construction

Using recycled plastics in construction presents several technical challenges, including:

Material Properties

Strength and Durability: Recycled plastics often have inferior mechanical properties compared to virgin plastics, including lower tensile strength and impact resistance. Consistency and Quality means the variability in the source and type of recycled plastic can lead to inconsistent material properties, affecting reliability in construction applications. Recycled plastics generally have higher thermal expansion coefficients than traditional construction materials, potentially leading to deformation under temperature changes.

Processing Issues

Contamination: Recycled plastics may contain impurities, contaminants, or mixed types of plastics that complicate the recycling process and reduce material performance. Sorting and Separation means effective sorting and separation of different plastic types are crucial to ensuring the quality of the recycled product, which can be labour-intensive and costly. Plastics can degrade during their lifecycle and the recycling process, leading to changes in chemical structure and properties.

Compatibility

Additive Compatibility: Ensuring compatibility of recycled plastics with necessary additives (e.g., stabilizers, plasticizers, fillers) is crucial for achieving desired material properties. About bonding with Other Materials, Achieving strong adhesion between recycled plastic components and other construction materials can be challenging.

Regulatory and Standards Compliance

Building Codes: Meeting existing building codes and standards with recycled plastic materials can be difficult due to variability and lack of long-term performance data. On health and Safety, Ensuring that recycled plastics do not emit harmful substances and meet health and safety standards is essential.

Economic Viability

Cost-Effectiveness: The cost of collecting, sorting, processing, and transporting recycled plastics can be high, making them less competitive compared to traditional materials. About Market Acceptance, There may be resistance from the construction industry and consumers regarding the use of recycled plastics due **to** perceived lower quality or durability.

Environmental Impact

Life Cycle Assessment: Comprehensive evaluation of the environmental impact of recycled plastics, including energy use and emissions during recycling and processing, is necessary to ensure true sustainability and end-of-Life Disposal, Planning for the end-of-life disposal or further recycling of construction materials made from recycled plastics is important to prevent additional waste.

Addressing these challenges requires continued research, innovation, and collaboration across industries to improve the quality, performance, and acceptance of recycled plastics in construction.

2.5.1 Innovative solutions for the above challenges

Using recycled plastics on construction presents various technical challenges, such as maintaining material properties and overcoming processing issues. I have tried to outline some innovative solutions addressing these challenges.

Material Property Enhancements

Additive Compounding: Incorporating additives such as stabilizers, filters and compatibilizers during the recycling process to enhance the mechanical properties and durability of the recycled plastics. This can improve strength, UV resistance and thermal stability.

Advance Recycling Techniques

Chemical recycling: unlike mechanical recycling l, chemical recycling breaks down plastics into their basic monomers. This process allows for the production of high- quality recycled plastics with properties comparable to virgin materials.

Pyrolysis and Gasification: Converting plastic waste into synthetic gas oil through high-temperature processes. These outputs can be used as feedstock for producing new plastics ensuring a closed-loop recycling system.

Enhancing Processing Technologies

Advanced Extrusion Techniques: Using co-rotating twin-screw extruders for better mixing and homogenization of recycled plastic materials. This ensures consistency quality and improved mechanical properties of the end product.

Injection Moulding Innovations: Implementing precise temperature and pressure controls in Injection moulding machines to process recycled plastic effectively, minimizing defects and Enhancing the structural integrity of moulded parts.

Quality control and Sorting

Automated Sorting Systems: Employing advanced sorting Technologies such as near-infrared (NIR) spectroscopy, AI and machine learning to accurately separate different types of plastics and contaminants. Improved Sorting leads to higher quality recycled materials.

Inline Quality Monitoring: Integrating real-time monitoring systems during the recycling process to detect impurities and ensure consistency quality. This helps in making immediate adjustments to maintain the desired material properties.

Nanotechnology Application

Nano-Additives: Introducing nanomaterial's such as grapheme, nanoclaysor carbon nanotubes to recycled plastics to enhance mechanical, thermal and barrier properties. These nano-additives can significantly improve the performance of recycled plastic composites.

Surface Modifications: Applying nano coatings or surface treatments to recycled plastics to enhance adhesion, resistance environmental factors, and overall durability.

Design Innovations

Modular Design**:** Creating construction components with modular designs can accommodate variations in recycled plastic properties. This approach allows for easier assembly and adaptability to different performance requirements.

Multi-Layer Structures: Developing multi-layer products where recycled plastics are used in non-critical layers, while critical layers are made from virgin or high performance materials. This ensures overall structural integrity while maximizing recycled content.

Standardization and Certification:

Material Standards: Developing and adopting industry- wide standards for recycled plastics to ensure consistency and reliability in their use. Standard help manufacturers and builders have confidence in the performance of recycled materials.

Certification Programs: Implementing Certification programs for recycled plastic products to verify their quality and compliance with industry standards. Materials can gain greater acceptance and trust in the market.

Collaborative Research and development

Public-Private Partnerships: Encouraging collaboration between research institutions industry players and government agencies to advance the development of recycled plastic technologies. Joint efforts can lead to innovative solutions and faster commercialization.

Open Innovation Platforms: Creating platforms for sharing knowledge, technologies and best practice related to use of recycled plastics in construction. This fosters innovation and accelerates the adoption across the industry.

2.6 Future trends and research gap

2.6.1 Gaps in the Current Literature

Long-term durability performance

Lack of Long-term studies: Moat studies focus on the short-term performance of plastic waste in construction materials, with limited research on long term durability, weathering effects and aging.

Real world performance data: There is need for data from real world applications rather than laboratory conditions to understand how plastic waste materials perform over extended periods under various environmental conditions.

Standardization and regulations

Absence of standardized methods: There is a lack of standardized methods and quality control procedures for incorporating plastic waste into construction materials.

Regulatory Frameworks: Few studies address the development of comprehensive regulatory frameworks to ensure the safe and effective use of plastics waste in construction.

Comprehensive environmental impact assessments

Incomplete life cycle analysis: while some research considers the environmental benefits of reducing plastic wastes, comprehensive life cycle analyses that include the entire production, usage and disposal phases are often missing.

Microplastic concerns: Potential issues related to the release of microplastics during the lifecycle of construction materials incorporating plastic waste have not been thoroughly investigated.

Mechanical properties performance

Inconsistent results: There is Inconsistency in the reported mechanical properties (e.g., strength and flexibility) of construction materials with plastic waste, which can be attributed to varying types of plastic, processing methods and proportion used.

Performance in composite materials: Limited understanding exists regarding the interaction between plastic wastes and other materials in composites, particularly concerning bonding, compatibility and overall structural performance.

Economic viability and scalability

Cost-effectiveness: Few studies provide a detailed economic analysis comparing the cost of plastic waste materials to traditional construction materials.

Scalability: Research often lacks discussion on the scalability of using plastic waste in construction, including supply chain logistics, production scalability and integration into existing manufacturing processes.

2.6.2 Suggested Areas for Future Research

Long-term Performance and Durability Studies: Conduct extensive real-world studies on the long-term performance of construction materials incorporating plastic waste and investigate the effects of environmental exposure, such as UV radiation, moisture, and temperature variations, on these materials.

Development of Standardized Testing and Regulatory Frameworks: Develop and validate standardized testing methods for evaluating the quality and performance of plastic waste materials in construction and collaborate with policymakers to establish clear regulatory guidelines and standards for the use of plastic waste in construction.

Comprehensive Environmental Impact and Micro plastic Studies: Perform full life cycle assessments to evaluate the environmental impact of plastic waste materials from production to disposal and investigate the potential release and impact of microplastics during the lifecycle of construction materials incorporating plastic waste.

Enhanced Understanding of Mechanical Properties and Composite Performance: Conduct systematic studies to understand the factors affecting the mechanical properties of plastic waste materials, including the type and proportion of plastic used and carefully explore the behaviour and performance of composite materials that combine plastic waste with other construction materials.

Economic Analysis and Scalability Assessments: Perform detailed economic analyses to assess the cost-effectiveness of using plastic waste materials compared to traditional materials. And I investigate the feasibility of scaling up the production and use of plastic waste materials, considering supply chain logistics and integration into current construction practices

2.7 Regulations and standards

Ensuring the quality and safety of recycled plastic materials in construction involves adhering to a variety of standards and certifications. These are developed by international, national and industry-specific organizations to ensure that recycled plastics meet stringent criteria from performance, safety and environmental impact.

- International Standards

ISO Standards

ISO 14021: This standard provides guidelines for environmental labels and declarations including specific criteria for claiming recycled content in materials.

ISO 9001: Focuses on quality management systems ensuring consistent production processes and quality control for recycled plastic materials.

- International Electro technical Commission (IEC)

IEC 62321: Specifies methods for the determination of certain substances in electro technical products, applicable to ensuring recycled plastics used in these products are safe

- European Standards

EN Standards

EN 15343: Provides standards for plastics recycling and includes procedures for traceability and conformity assessment of recycled content.

EN 13432: Specifies requirements for packaging recoverable through composting and biodegradation, which can be relevant for certain types de of biodegradable recycled plastics.

CE Making

The CE marking indicates the conformity with EU regulations, including the Construction Products Regulation (CPR), which ensures that construction products including those made from recycled plastics meet essential safety and performance requirements.

- United States Standards

ASTM International

ASTM D7209: Standard specification for polyethylene materials, recycled for moulded forms for use in construction.

ASTM D6270: Guide for the use of recycled plastics in the manufacture of rigid plastic containers. American Association of State Highway and Transportation Officials (AASTHO).

AASTHO M294: Standard specification for corrugated polyethylene pipe, which includes provisions for the use of recycled polyethylene.

- Certifications

Green Building Certifications

LEED (Leadership Energy and Environmental Design): Administered by the U.S Green Building Council LEED certification awards points for using materials with recycled content, promoting the use of recycled plastics in construction.

BREEAM (Building Research Establishment Environmental Assessment Method): Similar to LEED, BREEAM certification encourages the use of recycled materials in building projects to enhance sustainability ratings.

Cradle to Cradle Certified (CCC)

This certification assesses products for safety to human and environmental health, design for future uses cycles, and sustainable manufacturing practices. It applies to be wide range of products, including those made from recycled plastics.

Global Recycled Standards (GRS)

This standard verifies the recycled content of products, including recycled plastics, and ensures responsible social, environmental and chemical practices in their production.

- Industry-Specific Standards

American Concrete Institute (ACI)

Provides guidelines on the use of recycled plastic aggregates in concrete, ensuring that they meet the necessary strength and durability requirements.

National Roofing Contractors Association (NRCA)

Sets standards for the use of recycled plastics in roofing materials, focusing on performance and safety.

American Society of Civil Engineers (ASCE)

Provides guidelines and standards for the use of various recycled materials in civil engineering projects. Including recycled plastics.

- Key Quality and Safety Considerations

Material Performance

Standards ensure that recycled plastics meet specific criteria for mechanical properties, thermal stability and durability required for construction applications.

Health and Environmental Safety

Regulations often include requirements to ensure that the recycled plastics do not release harmful substances and are safe for human health and the environment.

Traceability and conformity

Standards such as EN 15343 emphasize traceability and conformity assessment ensuring that recycled plastics used in construction can be reliably traced back to their sources and meet all necessary regulations.

Third-Party Certification

Certification from recognized bodies provide assurance that recycled plastic materials meet high standards for quality, safety and sustainability making them more acceptable in the market.

Briefly the quality and safety of recycled plastic materials in construction are ensured through a robust framework of Standards and certifications that address various aspects of performance, health and environmental impact. Adherence to these standards and obtaining relevant certifications are crucial for the acceptance and effective use of recycled plastics in the construction industry.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

The purpose of this chapter is to outline the research methodology employed in this study. This methodology section is critical as it will provides a detailed account of the processes and techniques used to collect and analyse data, ensuring the study’s findings are credible and reproducible. This chapter will discuss the research design, data collection methods and sample selection criteria, data collection tools, data analysis procedure, validity and reliability, scope and delimitation, timeline and resources and the reflection.

3.1 Research Design

A research design is defined as the overall plan or structure that guides the process of conducting research. For the purpose of this study experimental research design will be used because it allows for precise control over the variables being studied and researchers can systematically vary the percentage of plastic waste used and directly observe its impact on the properties of the construction material.

By manipulating the independent variable (e.g., the proportion of plastic waste) and observing changes in the dependent variables (e.g., strength, durability, and workability of the concrete), experimental research can help establish causal relationships. This is crucial in determining whether the inclusion of plastic waste directly affects the performance of the construction material.

Experimental designs allow for the comparison of different conditions or treatments. For example, researchers can compare the performance of concrete with varying percentages of plastic waste to conventional concrete, providing a clear understanding of the benefits and drawbacks of using plastic waste and can also assess the environmental impact of using plastic waste in construction by measuring factors like leachate properties and lifecycle analysis, ensuring that the reuse of plastic is environmentally sustainable.

3.2 Data collection methods

3.2.1 Collection and treatment of plastic wastes

- Source Identification: we identified sources of plastic waste such as recycling centres, manufacturing waste, municipal solid waste or post-consumer plastic products.
- Segregation: we segregated plastic waste based on type (e.g., PET, HDPE, LDPE, PP) to ensure uniformity in the final concrete mix. This is important as different types of plastics have different properties.
- Washing: we cleaned the collected plastic waste to remove contaminants like dirt, labels, adhesives and any other impurities. This can be done using water and detergents.
- Drying: we dried the cleaned plastic waste thoroughly to remove moisture, which could adversely affect the concrete mix.
- Shredding: the knife was used to cut the plastic waste into smaller pieces. The size of the pieces had to be close to the size of fine aggregates but it was almost impossible because the Shredder machine was not available, so the plastic wastes was cut manually using a sharp knife.
- Sieving process: we sieved the ground plastic to obtain a uniform particle size. This helps in ensuring consistent mixing and performance in the concrete and it's recommended to use standard sieves to classify the particles.
- Separation: the plastic particles had to be separated into different size fractions to match the grading of fine aggregates used in the concrete mix.
- Physical properties: we analysed the physical properties of the prepared plastic waste particles, such as particle size distribution, shape and texture.
- Chemical properties: the chemical analysis was conducted to identify any potential adverse reactions with cement or other components of the concrete.
- Proper Storage: after we stored the prepared plastic waste particles in a dry, clean environment to prevent contamination and moisture absorption before use in concrete mixing.

3.2.2 Collection of coarse, fine aggregates and cement

Fine aggregates

- The first step was to identify reliable suppliers or source of fine aggregates such as natural sand, manufactured sand or crushed stone dust.
- We removed any impurities such as organic matter, clay or silt by washing the aggregates. This is essential for maintaining the quality of the concrete mix.
- After we dried the washed aggregates to a constant weight to ensure there is no moisture content that could affect the mix design.
- Then we conducted a sieve analysis to determine the particle size distribution to ensure that the fine aggregates meet the required specifications for use in concrete.

Coarse aggregates

- Firstly we identified reliable sources of coarse aggregates such as gravel, crushed stones or recycled concrete aggregates.
- We then washed the coarse aggregates to remove dust, dirt and other impurities. Clean aggregates improve the bond with cement paste.
- The washed aggregates was dried to a constant weight to avoid any moisture-related issues in the concrete mix.
- Then we performed a sieve analysis to determine the grading of coarse aggregates. To ensure that the aggregates meet the necessary specifications for concrete.

Collection of cement

- We needed to identify reliable suppliers of cement to ensure that the cement type (e.g., Ordinary Portland Cement, lime Cement) is suitable for the study.
- Then we obtained representative sample of cement from different batches to ensure consistency. Follow standard sampling procedures.
- The cement had to be stored in a dry, cool place to prevent it from absorbing moisture and becoming unusable. It’s better to use airtight containers if necessary.

- It’s necessary to perform tests to ensure the comments the required standards (e.g. compressive strength, setting time, fineness). And it’s also mandatory to verify the cement’s certification and batch details from the supplier.

3.3 Data collection tools

Plastic Shredders and Granulators: For processing plastic waste into suitable sizes for use as fine aggregates.

Figure 3.1: Plastic Shredder

Mixers: Concrete mixers to ensure homogeneous mixing of plastic aggregates with cement and other materials.

Figure 3.2: Mixer

Weighing Scales: Precision scales to measure the weight materials accurately.

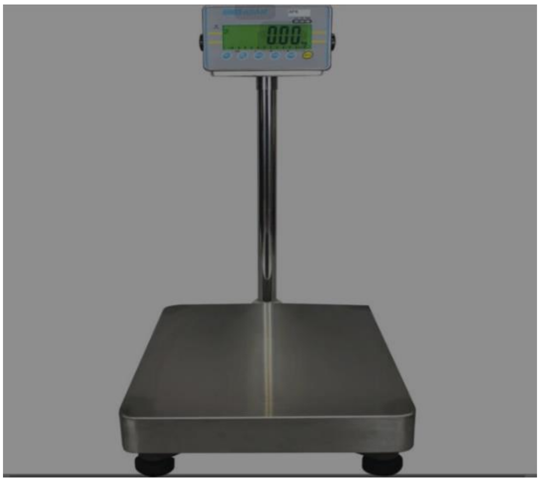

Figure 3.3: Weighing Scale

Mixing Tools: Tools for manual or mechanical mixing of concrete.

Figure 3.4: Mixing Tools

Casting Moulds: Standard moulds for forming concrete specimens (cylinders, cubes, beams).

Figure 3.5: Casting Mould

Curing Tanks: For water curing of concrete samples.

Figure 3.6: Curing Tank

Compression Testing Machine: To measure the compressive strength of concrete samples.

Figure 3.7: Compression testing machine

Slump Cone: For measuring the slump and workability of fresh concrete.

Figure 3.8*:* Slump Cone

3.4 Data analysis procedures

The initial step in this data analysis process is an extensive literature review. This involved gathering information from academic journals, industry reports and case studies to understand the current state of research on using plastic wastes in concrete. This provided a foundational understanding of previous findings, methodologies and gaps in research. This background knowledge helps in formulating hypotheses and designing experiments that are both innovative and scientifically sound.

The next step involved the collection and preparation of materials. This includes sourcing plastic wastes, which can be collected from various sources such as bottles, bags and packaging materials. The plastic wastes was processed into small, uniform pieces to ensure consistency in the concrete mix. Alongside this, traditional concrete components like cement, coarse aggregates and fine aggregates were prepared. The preparation stage is crucial as it ensures the materials are ready for the subsequent mixing and testing phases.

Creating concrete amices with varying proportions of plastic waste was the next critical step. A control mix with 0% plastic waste serves as a benchmark. Subsequent mixes were prepared with incremental replacements of fine aggregates by plastic waste, typically ranging from 5% to 25%. The preparation of these mixes must adhere to standard concrete mixing procedures to ensure that any observed differences in properties are attributable to the plastic waste content rather than variations in mixing methods.

Before the concrete hardens, its fresh properties tested. The primary focus here is on workability, which is assessed through slump test and compaction factor tests. These tests determine how easy it is to mix, transport and place the concrete. Fresh concrete properties are essential because they influence the concrete's performance and quality in its hardened state.

Once the concrete has set and hardened, a series of tests are conducted to evaluate its mechanical and durability properties. Among those tests there are Compressive Strength Test which measures the ability of the concrete to withstand loads that tends to reduce size causing deformation which can lead to serious damage, and it is conducted at intervals of such 7,14 and 28 days of curing. Flexural Strength Test that assesses the concrete's ability to resist bending. Splitting Tensile Strength which evaluates the tensile strength of the concrete and the Durability Tests to examine properties like water absorption, permeability, freeze-thaw and resistance to chemical attacks.

Accurate and systematic data collection is essential for meaningful analysis. All measurements from various tests were meticulously recorded, ensuring data from each mix and tests are documented. Based on the analysis and discussion, the study concludes the viability of using plastic wastes in concrete then the recommendations will be provided for practical applications, suggesting optimal replacement levels and potential areas for further research. There recommendations are crucial for practitioners and researchers aiming to implement or expand upon this innovative approach.

The final step involved documenting the entire process and findings in a detailed report, this includes the methodology, data analysis, discussions and conclusion, providing a comprehensive account of the research. This documentation is essential for knowledge dissemination and serves as a reference for future studies.

3.4.1 Laboratory tests

3.4.1.1 Slump test

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The inexpensive test which measure consistency, is uses on either construction sites or in engineering laboratory to determine whether concrete batch should be accepted or rejected.

Test objectives

The slump test is used to determine the consistency or workability of concrete

Test apparatus

The test apparatus used to perform the slump test were, a slump Cone (Abrahams cone), a several type of aggregate, Portland cements, clean water and trowel.

Test procedure

Clean the internal surface of the mould and apply oil. Place the mould on a smooth horizontal non-porous base plate and fill the mould with the prepared concrete mix in 4 approximately equal layers with tamp of each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould.

For the subsequent layers, the tamping should penetrate into the underlying layer and remove the excess concrete and level the surface with a trowel, clean away the mortal or water leaked out between the mould and the base plate and rise the mould from the concrete immediately and slowly in vertical direction. Finally measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

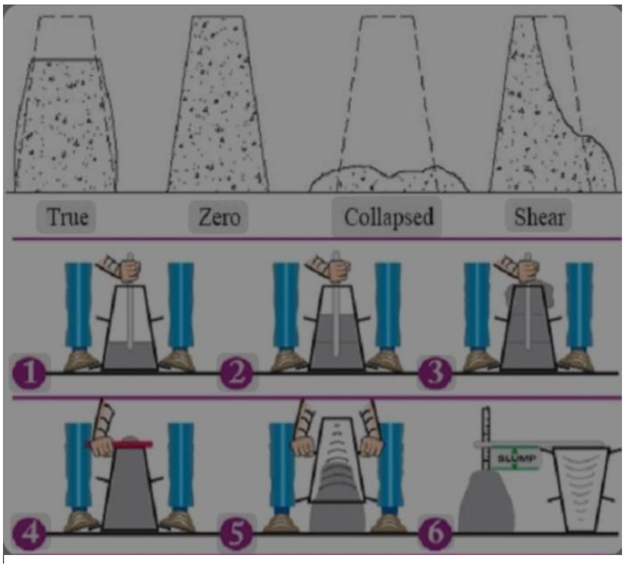

Figure 3.9: slump test procedure

3.4.1.2 Water absorption test

The water absorption test on concrete cubes is done to measure the ability of concrete to absorb water, which is the indicator of porosity and durability. This test helps in assessing the quality of concrete especially in terms of its resistance to water penetration.

Test objective

The main objective of the water absorption test is to assess the porosity and water absorption capacity of the concrete.

Test apparatus

To perform this test first of all we had 150mm*150mm*150mm concrete cubes, an oven capable of heating to 100°C to 110°C, a weighting balance with 0.1g accuracy, curing tank and cloths for drying.

Test procedures

We took a concrete sample that has been cured for 14 days, we ensured the surface is clean and free from any foreign matter and it was placed in an oven at a temperature of 105°C for 24 hours so that it will reach a constant mass. After drying the cube was removed from the oven to allow it to cool down to room temperature, we weighted the cubes on the weighting balance then we recorded the dry weight (Wd). The dry cubes were fully submerged in water for a period of 24 hours. After the cubes had to be removed from water to be wiped with damp cloth only to remove the surface water without letting it absorbing water from the cubes pores, then we weighted them to record the saturated weight (Ws). The water absorption percentage is calculated using the following formula:

$$\text{Water absorption (\%)} = \frac{Ws-Wd}{Wd} * 100$$

Compressive strength

Compressive strength results are used to ensure that the concrete mixture as delivered meets the requirement of the specimen of the specified strength in the job specification. The strength from cast cylinders may be used for quality control, acceptance of concrete, for estimating the strength in the structure or evaluating the adequacy of curing and protection afforded to structure.

Test apparatus

The test apparatus used to perform the compressive strength were, concrete cubes and compression Testing Machine.

Test procedures

After the cubes have attained the required age of tasting, that’s 7, 14 and 28 days, they were removed from the curing tank and wiped to remove surface moisture in readiness for a compression test. The specimens were then weighted and the weight was recorded for the purpose of density computation. After all, the cubes were placed in the compressive strength testing machine one by one by making sure that the cubes are well positioned in the machine. The enter button was pressed followed by start button for loading. Once the reading started moving backwards as the curve becomes constant, the stop button was pressed and the readings on the dial gauge were recorded for each cube.

3.5 Limitations of the study

3.5.0 Introduction

Despite the comprehensive approach outlined, several limitations could affect the validity, reliability and generalizability of the findings. These limitations needs to be acknowledged and addressed in future research.

3.5.1 Material Variability

Plastic waste Characteristics such as heterogeneity which means plastic waste comes in various types, such as PET, HDPE and LDPE, each with different properties. The analysis might not account for the specific effects of different types of plastic and the plastic waste may contain contaminants (e.g., food residue, labels), which can affect the concrete properties and complicate the analysis. The properties of fine and coarse aggregates can vary based on their source. Different sources might lead to variations in results.

3.5.2 Scale of Experimentation

Laboratory Conditions like controlled environment indicate that the experiments are typically conducted in controlled laboratory conditions. This may not accurately reflect real-world conditions where factors such as weather, site preparation, and handling vary and actually the study is usually performed on small-scale samples, which might not capture the complexities of large-scale concrete applications.

3.5.3 Long term Durability

Durability assessment like Short-term Testing clearly explains that most tests like compressive strength and durability are conducted over relatively short periods (e.g., 28 days). And Long term performance, such as the effects of aging, sustained loading and prolonged environmental exposure is not assessed and long term environmental impact of using plastic waste in concrete such as leaching of chemicals was not typically evaluated.

3.5.4 Economic feasibility and scaling

The analysis may not consider the cost of implications, cleaning, processing and incorporating plastic waste into concrete and the practicality of scaling up to the process of large scale construction projects is not evaluated.

3.5.5 Limited scope of Testing

Comprehensive testing indicates that while the study covers essential mechanical properties (compressive strength) other important aspects such as impact resistance, fatigue strength and creep behaviour might be overlooked and only few durability properties might be tested. Comprehensive testing for various chemical exposures (e.g., sulphate attack, chloride penetration) may be missing.

3.5.6 Environmental and health concerns

The potential for microplastic generation during the mixing, curing, and aging of concrete is not assessed and the health risks associated with handling and processing plastic waste are not considered in this study. A complete lifecycle analysis, considering the environmental impact from production to disposal, is often not included.

3.5.7 Statistical Limitations

Sample Size indicate that the number of samples tested may be limited, which can affect the statistical power and reliability of the results.

3.6 Addressing the Limitations

To mitigate these limitations, future research could:

Include a variety of plastic types and ensure thorough cleaning and processing to standardize the material as much as possible.

Expand the scale of experimentation to include field trials and long-term performance studies.

Incorporate a comprehensive cost analysis and evaluate the economic feasibility of large-scale implementation.

Broaden the scope of testing to cover a wider range of mechanical and durability properties.

Conduct a lifecycle analysis to assess the environmental impact comprehensively.

Increase the sample size and replicates to improve the statistical robustness of the findings.

3.7 Validity and Reliability of the data

3.7.1 Validity

Internal validity refers to the extent to which a study accurately establishes a cause-and-effect relationship between the independent and dependent variables. In the context of my topic internal validity was ensured by carefully controlling experimental conditions, such as the type and amount of plastic waste used, mixing procedures, curing conditions, and testing protocols.

Even if my study focused on internal validity it’s better to understand about external validity too, and this addresses the generalizability of the study findings to real-world situations. To achieve external validity in research on plastic waste as a partial replacement for fine aggregates, experiments should be conducted under various realistic conditions that reflect actual construction scenarios. This includes testing different types of plastic waste, concrete mix designs, and environmental conditions. Comparing the study results with those from field studies and other literature can further establish external validity.

3.7.2 Reliability

Test-retest reliability measures the consistency of results over time. For studies like this involves repeating experiments under identical conditions to ensure that the findings are stable and reproducible. Consistent results across multiple trials indicate high test-retest reliability. Inter-ratter reliability assesses the degree of agreement between different researchers conducting the same study. To achieve inter-ratter reliability, it is important to have clear and standardized protocols for conducting experiments and analysing data. Training researchers, using calibrated equipment, and ensuring uniformity in procedures can minimize variations and enhance reliability.

Internal consistency reliability examines the consistency of results within a single study. For instance, if multiple samples of concrete with plastic waste are tested, the results should be consistent across all samples. Using homogeneous materials, precise measurements, and replicable procedures contribute to high internal consistency reliability.

3.8 Case Study

3.8.1 Introduction

There are numerous studies that sought to investigate the effect of adding PET to concrete and in various manner, such as adding it as fine aggregate, flakes or by adding it as fibers to concrete. Also, there are other studies that have investigated the possibility of utilizing PET bottles by adding full of sand inside and using it in wall construction. Observed that using plastic waste as a partial substitute of fine aggregates at a rate of 20 % led to a decrease in the slump and compressive strength by 25 and 72 %, respectively.

According to the investigation conducted, it was concluded that the use of PET waste in a concrete mixture as irregular fiber results in an improvement of the compressive, tensile strength and modulus of elasticity. Observed an improvement in the mechanical characteristics of concrete when PET waste was incorporated with concrete as a fiber with varying ratios.

3.8.2 Materials

3.8.2.1 Cement

A commercial Ordinary Portland cement locally available was employed in this study. It is conforming to Iraqi Standard Specification IQS NO.5 [13]. The chemical composition and physical properties of using cement are listed in Tables 1 and 2, respectively

Table 3.1: Chemical composition of the ordinary Portland cement

Property	Test result [%]	Standard
Oxide composition		
Alumina, Al_2O_3	4.23	
Silica, SiO_2	20.92	
Ferric Oxide, Fe_2O_3	3.76	
Lime, CaO	59.81	
Sulphuric anhydride, SO_3	2.11	Max. 2.8
Magnesia, MgO	3.14	Max. 5
Compound composition		
C_3A	4.89	

C_2S	29.33	
C_3S	40.63	
C_4AF	11.44	
Free Lime	0.97	
Loss on ignition	2.22	Max. 4
Solid Solution	15.31	
Insoluble Residue	1.38	

Table 3.2: Physical properties of the used cement

Property	**Test result**	**Standard IQS, NO. 5 2015**
Initial setting time	120	≥45
Final setting time	240	≤600
Compressive strength[MPa]		
at 3 days	34.9	≥15.0
at 7 days	38.9	≥23.0

3.8.2.2 Fine aggregate

Clean river sand with maximum aggregate size of 4.75 mm was used as a fine aggregate. The results of the sieve analysis test show that the grading of fine aggregates complies with the limits of the ASTM C33 specification. The grading and physical properties are illustrated in Tables 3 and 4, respectively.

Table 3.3: Physical properties of fine aggregates

Type of the aggregate	**Medium sand**
Colour	Brown
Specific Gravity S.S.D basis	2.68
Absorption	1
Compact unit weight [kg/m^3]	1981
Loose weight[kg/m^3]	1833
Fineness modulus	3.02

Table 3.4: Sieve analysis of fine aggregates

Sieve size[mm]	%Specification limits according to ASTMC 33-99a	Passing of used sample[%]
4.75	89-100	99.5
2.36	60-100	78
1.18	30-100	58
0.6	15-100	40.5
0.3	5-70	16
0.15	0-15	6

3.8.2.3 Coarse aggregate

A river rounded gravel with a maximum aggregate size of 19 mm was used in this study. The results of sieve analysis test reveal that the grading of coarse aggregates is in accordance with ASTM C33 specification limits [14]. Tables 5 and 6 display the grading and properties of normal coarse aggregate**.**

Table 3.5: Grading of normal coarse aggregate

Grading of coarse aggregates M.A.S 20 mm		
Sieve size [mm]	**Specification according to ASTM-C33-99a[%]**	**Passing of used sample[%]**
25	100	100
19	90-100	95
9.5	20-55	38
4.75	0-10	0
2.36	0-5	0

Table 3.6: Properties of coarse aggregates

Types of coarse aggregates	Rounded gravel
Specific gravity S.S.D	2.36
Absorption [%]	0.25
Compact unit weight [kg/m^3]	1087
Loose unit weight [kg/m^3]	1689
Angularity index	0.74

3.8.2.4 PET fibers

PET wastes were prepared by collecting mineral water bottles and excluding the neck and bottom of the bottle and removing the trademarks applied to it to obtain a homogeneous fiber. Thereafter, the bottles were cut into fibers with a constant thickness of 0.13 mm. Three different fiber sizes were used in this research work. The first with a length and width of approximately 45 and 4 mm, respectively. The second with a length and width of approximately 22 and 4 mm, respectively. While the third was a mix of the previous two sizes 45 mm and 22 mm. Fig. 11 shows the shapes of shredded PET fibers waste.

Figure 3.10: PET waste fibers used in this study.

The current study, 10 concrete mixtures were cast with weight ratios (cement: sand: gravel) that are 1: 2: 4 and with a water/cement ratio of 0.58. The materials used in preparing the concrete mixes were in dry condition. One of the mixes was without plastic fibers, as it is considered the reference mix. The other 9 mixtures were divided into three groups, the only variables were the dimensions of the plastic fibers. The first group contains plastic fibers with 45 mm length and consists of three mixes in which the variable is the percentage of the plastic fibers 0.1, 0.3, and 0.5 % of the cement weight. The second group contains plastic fibers with a length of 22 mm that having three mixes with different ratios of plastic fibers. The last group was the combination of the two previous fiber lengths 45 and 22 mm, respectively, which also consists of three mixes in which the only variable is the proportion of the plastic fibers. Table 7 lists the proportions of concrete mixes and plastic fiber dosages. In order to obtain the compressive strength of all concrete mixtures, concrete cubes with dimensions of 100 × 100 × 100 mm were prepared. Afterwards, the test was conducted according to the specifications BS 1881: Part 116 for different curing periods 3, 7, 28 and 56 days in which three samples were tested for each curing period and their average was then calculated. While for the tensile strength and flexural strength of the mixtures, two concrete cylinders of dimensions 100 × 200 mm were cast for each percentage of the added fibers and three concrete prisms 100 × 100 × 500 mm, and the average values were calculated. These tests were conducted on the samples at age 28 days according to ASTM C496/C496 M and ASTM C293/C293.

Table 3.7: Concrete mixture proportions

Group	PET fibers [%]	Cement [kg/m^3]	Sand [kg/m^3]	Gravel [kg/m^3]	Water [kg/m^3]	Mix proportion
Control	0	300	600	1200	174	1:2:4: 0.58
Group1(fiber length=45mm)	0.1	300	600	1200	174	
	0.3	300	600	1200	174	
	0.5	300	600	1200	174	
Group2(fiber length=22mm)	0.1	300	600	1200	174	
	0.3	300	600	1200	174	
	0.5	300	600	1200	174	
Group3(fiber length=45+22mm)	0.1	300	600	1200	174	
	0.3	300	600	1200	174	
	0.5	300	600	1200	174	

3.8.3 Results and discussion

3.8.3.1 Slump test results

The overall results of the slump test for all concrete mixes and for all ratios of plastic fibers added, which were carried out according to ASTM C143 are shown in Fig.12. Based on Fig. 12, it can be clearly observed that the addition of P ET wastes has a negative effect on the workability of the concrete mixtures and this conclusion has been drawn by many researcher. The concrete mixture containing 0 % of PET wastes has the highest slump value of 120 mm, and with the addition of PET wastes, the workability gradually decreased.

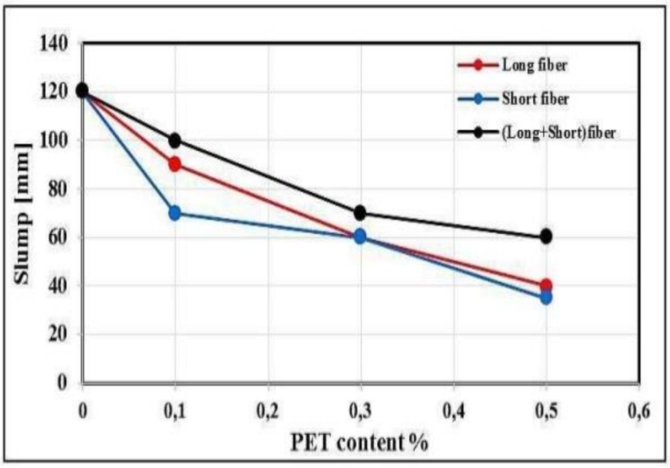

Figure 3.11: Slump test results

The results also show that the workability of concrete decreases with increasing the percentage of addition of PET wastes. The amount of reduction in the slump value, when adding the long fibers, reached 25, 50, and 66.7 % for the corresponding ratios of 0.1, 0.3, and 0.5 %, respectively. While for the short fibers, the amount of decrease in the sump value was 41.7, 50, and 70.8 % for the proportions 0.1, 0.3, and 0.5 %, respectively. Finally, the decrease in the amount of slump for the mixed fibers (long + short) was 16.7, 41.7, and 50 % for the ratios 0.1, 0.3, and 0.5 %, respectively. The reason for the reduction in the amount of slump compared to the control mix is attributed to the fact that the presence of plastic fibers waste works to restrict the concrete flow and movement of aggregates.

Figure 3.12: Slump test and concrete flow

3.8.3.2 Concrete compressive test results

The concrete compressive strength results for curing periods 3, 7, 28, and 56 days and for added PET wastes with different proportions are shown in Figs. 4-6. It can be noticed from

The results that the addition of PET wastes has a slight effect on improving the compressive strength of concrete. The results of previous research studies revealed that the addition of this material tends to increase the compressive strength up to a certain percentage, and then by increasing its percentage, the compressive strength of the concrete decreases.

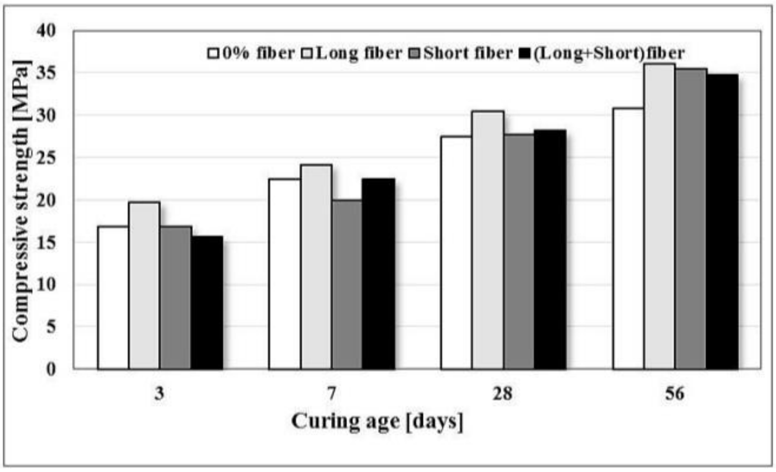

Figure 3.13: Compressive strength of concrete containing 0.1 % PET fiber.

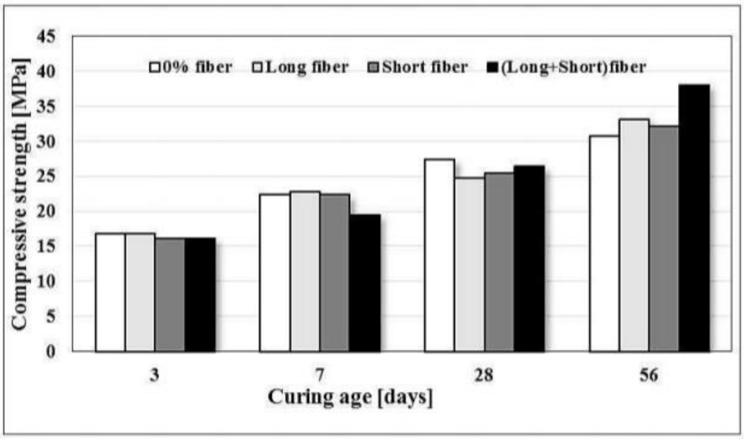

Figure 3.14: Compressive strength of concrete containing 0.3 % PET fiber

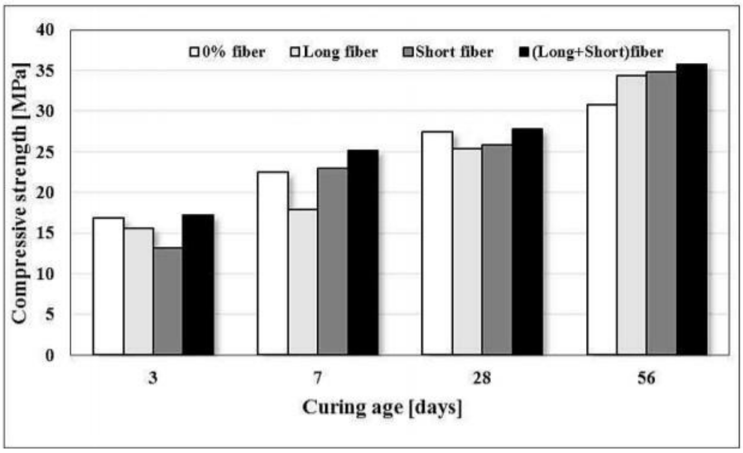

Figure 3.15: Compressive strength of concrete containing 0.5 % PET fiber

The addition of 45 mm PET wastes to the concrete mixture at a rate of 0.1 % of the cement weight led to an increase in the compressive strength up to 10.8 and 17.2 % at curing ages 28 and 56 days, respectively as compared to the reference mixture. Whereas, the addition of PET wastes at a ratio higher than 0.1 % led to a reduction in the compressive strength by 9.5 and 16.7 % corresponding to 0.3 and 0.5 % of fiber wastes, respectively, at age of 28 days. Likewise, when adding plastic waste fibers with a length of 22 mm, these fibers increased the compressive strength up to 0.9 and 15.2 % when added by 0.1 %, at ages 28 and 56 days, respectively. Thus, the increase in the addition ratio of PET wastes decreased the compressive strength of the concrete mixes. Similarly, it can be seen that adding plastic fiber wastes in the form of a combination of the two previous sizes 45 + 22 mm increases the compressive strength when adding fibers by 0.1 %, as the increase in compression strength reached 2.8 and 13 % at the ages of 28 and 56 days, respectively. The reason for this reduction in the compressive strength of concrete containing plastic fiber wastes is attributed to the weak bonding and interaction between the smooth surface of the fibers and the cement paste. Moreover, the plastic waste is characterized by not absorbing water, which in turn will impede the penetration of water into the concrete and thus affect the cement rehydration process.

When comparing the mixtures having an addition ratio of 0.1 % of the cement weight, it can be noticed that mixtures containing long plastic fibers have the highest values of compressive strength at all ages. While, the increase in the addition amount of these fibers leads to a decrease in the compressive strength values. This might be attributed to that the long plastic fibers tend to clump together more than short fibers [19]. Thus, these will be weak characteristics as they are acting as the voids and hence affect the density of concrete, which negatively influences the compressive strength.

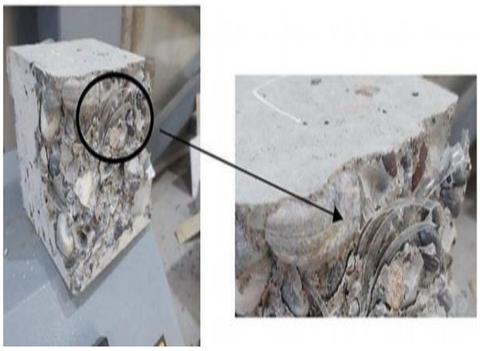

Figure 3.16: Clumping of long fibers inside the concrete.

While for the addition ratios of 0.3 and 0.5 %, it is obvious that the compressive strength of mixtures containing mixed lengths of both long and short plastic fibers is better than the other two mixture types. This is because adding fibers of different lengths will have better spread and dispersion inside concrete than adding long fibers only. In addition to that, the different lengths of plastic fibers will act as bridges to connect and prevent the formation of micro cracks.

This study demonstrated the possibility of incorporating plastic wastes in the form of fibers into concrete and achieving adequate compressive strength. On the other hand, the use of these wastes in concrete saves the environment and energy.

3.9 Reflexion

I have Chosen to study on this topic because incorporating plastic waste into concrete helps reduce the amount of plastic that ends up in landfills and oceans and it decreases the demand for raw materials, preserving natural resources and reducing the environmental footprint of concrete production.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 introduction

After testing conducted on samples, the results obtained from the laboratory had to be analysed because those results reflects the properties of the concrete. Analysis of results is important to highlights the findings whether the objective achieved or not. Several tests was conducted on the mix sample of plain concrete which means with 0% of plastic wastes and other one which contain 8.8% of HDPE plastic wastes. The tests were carried out on fresh concrete and hardened concrete. For hardened concrete the mix samples needs to undergo curing process of 7, 14 and 28 days.

4.1 Materials

The materials used were the following, ordinarily Portland cement, coarse aggregates, fine aggregates, plastic wastes and water. The coarse and fine aggregates used in this study was already in ULK engineering laboratory. The shape and quality of aggregates was trusted and it was free from impurities. HDPE plastic waste used in this study were collected from local dump yard before being treated. Water was fetched from one of institutional water taps and it was free from physical impurities.

The cement used for current experimental analysis was cheetah Portland cement of 32.5 grade from a new cement manufacturing plant located about 50 km southwest of Kigali in Muhanga district. The origin of fine and coarse aggregates mostly used in Kigali city is

Figure 4.1*:* Cement used in the study

Rusine quarry.

4.2 Mix design

In order to avoid wastage we calculated the mix design according to the volume of testing cubes, then we multiplied our mix by the cubes we needed and with respect to the substituent replacement of plastic on some testing cubes.

The volume of one concrete cube is 0.00337 m^3

Mix design ratio is 1:1.5:3 of M20 concrete

4.2.1 Step by step calculation

Sum of mix proportions= 1+1.5+3=5.5

The wet volume is 0.00337m and the dry volume=0.00337m*1.54=0.00519 m^3

4.2.1.1 Volume and weight of cement

Volume of cement=0.00519*1/5.5=0.000943 m^3

Density of cement is 1440 kg/m^3

Weight =volume*density

Weight of cement=0.000943 m^3*1440=1.36 kg

4.2.1.2 Volume and weight of fine aggregates

Volume of fine aggregates=0.00519*1.5/5.5=0.001415m

Density of fine aggregates is 1600kg/m

Weight of fine aggregates=0.001415 m^3*1600 kg/m^3=2.26 kg

4.2.1.3 Volume and weight of coarse aggregates

Volume of coarse aggregates=0.00519*3/5.5=0.002829 m^3

Density of coarse aggregates is 1450 kg/m^3

Weight of coarse aggregates=0.002829*1450=4.10 kg

4.2.1.4 Quantity of water

1kg of water=1liter

Quantity of water=quantity of cement*w/c ratio

Quantity Of water=1.36*0.55=0.74 kg or litres

4.2.1.5 Amount of plastic wastes

The total weight of HDPE plastic flakes we had was 0. 4 kg

Percentage=$\left(\frac{part}{whole}\right) * 100$

By substituting the values we found out that we had 0.088 which is 8.8% of plastic waste

Figure 4.2: Plastic flakes on fine aggregates

Figure 4.3: Mixing

4.3 Slump test results

This test was carried out to compare the workability concrete of the control mix and the partial replacement mix.

Figure 4.4: Slump test

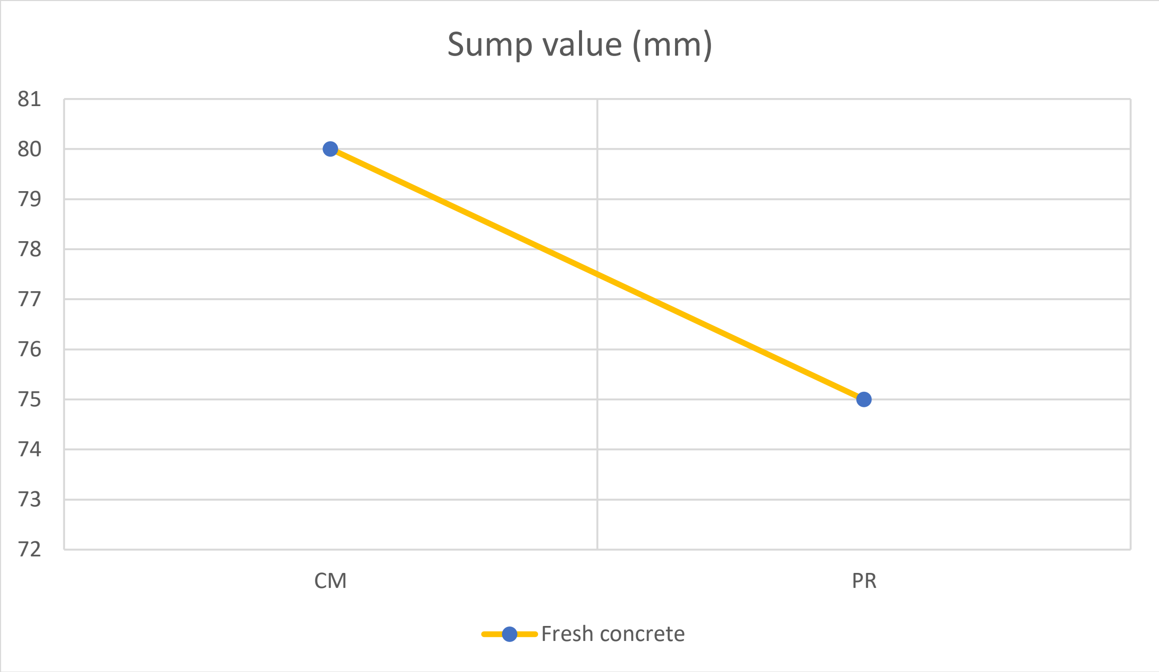

Figure 4.5*:* Slump value

According to the slump test results shown in the above chart, the control mix had 80 mm slump while the mix containing plastic wastes had 75 mm slump. The 80 mm slump indicates a moderately workable mix suitable for general construction where workability and strength are well balanced. A 75 mm slump indicates a slightly stiffer mix than plain concrete but it is still workable and accepted. The presence of plastic wastes can reduce the density without drastically affecting its workability. The slump for the plain concrete is well established choice for most structural applications and the one of the mix with 8.8% plastic wastes provides a more sustainable alternative with marginally reduced workability but has environmental benefits and potential in low load applications.

4.4 Water absorption test results

Firstly we had to find the dry and saturated weight of both plain concrete and concrete with plastic weight, as we know the dry weight is the weight of the sample after spending 24 hours in the oven on at least 105°C temperature and the saturated weight is that weight of the sample after 24 hours in the curing tank. This test was done on concrete samples after 7 days of curing.

Table 4.1: Sample weights

Type of mixture	Dry weight(Wd)	Saturated weight(Ws)
Control mix	7.6	7.9
Partial replacement	7.4	7.7

To determine the water absorption percentage we use the below formula:

$$\text{Water absorption (\%)} = \frac{Ws - Wd}{Wd} * 100$$

On concrete with 0% of plastic waste= $\frac{7.9\ kg - 7.6\ kg}{7.6\ kg} * 100 = 3.9\%$

On concrete with 8.8% of plastic waste= $\frac{7.7\ kg - 7.4\ kg}{7.4\ kg} * 100 = 4\%$

As we see there is only 0.1% increase in water absorption on plastic mix compared to the control mix and as far as I know that difference might have been occurred because of some little voids left by plastics not binding with cement as fine aggregates can.

Figure 4.6: Dry weight of a concrete cube

4.5 Compressive strength test results

Compressive strength is the most significant mechanical property of concrete. It is obtained by measuring concrete specimen ability to withstand compression load after curing for 28, days but sometimes it can also done after 7 or 14 days according to the purpose and methodology of the study. Some of the factors that influence the concrete strength include aggregate quality, cement strength, water content and water/cement ratio, cubes that were used in this compressive test had measurements of 150mm*150mm*150mm each. For us we did this test at all three stages of curing.

Figure 4.7: Sample in a compression machine after being crushed

Table 4.2: Compressive test results

Mixing sample	Mass of specimen	Breaking load in KN	Compressive strength Mpa	Average of compressive strength	Reduction strength (%)
Compressive strength after 7 days					
CM	7.6	440.3	19.5	19.2	
	7.5	429.5	19		
PR (8.8 %)	7.4	331.4	14.7	14.4	25%
	7.2	319.6	14.2		
Compressive strength after 14 days					
CM	8.1	461.3	20.5	21.1	
	8.3	488.7	21.7		
PR(8.8%)	7.7	453.8	20.1	19.8	6.1%
	7.6	441.4	19.6		
Compressive strength after 28 days					
CM	8	650.2	28.9	29.7	
	8.4	688.5	30.6		
PR (8.8%)	7.9	639	28.4	28	5.7%
	7.8	632.2	27.7		

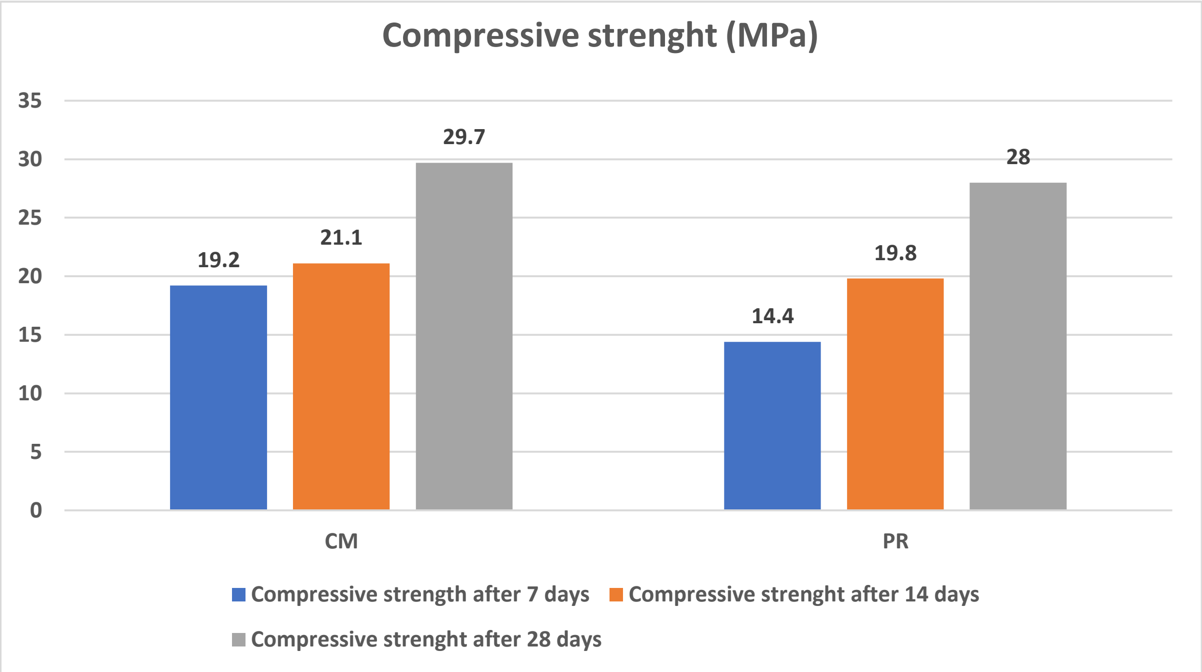

Figure 4.8: Compressive strength chart

Above there is chart of concrete compressive strength after undergoing the curing process of 7, 14 and 28 days. From an overall view, the chart shows the decrease in concrete strength when we added some percentage of plastic waste as partial replacement of fine aggregates compared to our control mix. The control concrete mix has the highest compressive strength which is 21.1 MPa after 14 days of curing compared to the other sample with plastic flakes which has 19.8 MPa. In the mixed sample, the fine aggregates was replaced by plastic flakes by 8.8 percentage (PR), the concrete compressive strength was reduced by 6.1% when compared to the control mix (CM). After 28 days of curing the compressive strength of sample containing amount of plastic waste had visibly increased to 28 MPa but compared to the other its low because the control mix had 29.9 MPa after same days of curing, indicating the decrease in compressive strength by 5.7%. based on the above results, we can conclude that using 8.8% of HDPE plastic flakes as partial replacement of fine aggregates in concrete has no much negative effect on concrete because even if the compressive strength had reduced it fall above 20 MPa which is considered as the minimum compressive strength of M20 concrete, so it is accepted.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 CONLUSION

The general objective of this study is to indicate that it is possible to reduce plastic wastes that are thrown into our environment by recycling them into useful materials in our Construction industry. Growing amount of plastic wastes in our ecosystem can be tackled by its recycling in effective and beneficial manner. In this study we focussed summary of research work being carried out to exploit plastic wastes as a constituent construction material.

The workability of fresh concrete containing recycled plastic was reduced due to non-uniform and irregular shapes of particles. This condition negatively affected the workability of the mix. The concrete mix without plastic wastes had shown higher strength than the other containing plastic wastes, a concrete cube after 28 days of curing demonstrated the maximum compressive strength of 650.2 KN (0 percent plastic waste) while the other cube with 8.8% HDPE plastic flakes had 639 KN. The lessening of adhesion between plastic particles don't seem to be connected very well. However since the water absorption percentage is low, it appears that cement and plastic waste can be combined. It could have been better to apply all the tests which are conducted on concrete but it was not possible according to the capacity of the laboratory but I appreciate for the ones that were available. As the general conclusion, adding plastic flakes as partial replacement of fine aggregates in concrete reduces its workability and compressive strength of but as the tests shows the results fall within the accepted range to be used in construction. Our purpose was not to increase the mechanical and physical characteristics of concrete but to save our ecosystem which is daily damaged by plastic wastes. According to our study and existing reviews, we have seen that with the increase of the amount of plastic in the concrete mix, the characteristics reduces which may seriously affect the concrete.

5.1 RECOMMENDATIONS

Clearly plastic waste can prove to be a sustainable additive and partial replacement of conventional construction materials, thereby addressing the dual issues of management of plastic wastes and helping in the reduction of footprints caused by construction industry on the environment. However the long road is ahead before the commercial implementation of the idea can be realized. More research is required to fully understand the advantages and limitations of plastic waste-based construction materials qualitatively and quantitatively.

1. A feasibility study should be completed on the use of plastic as partial replacement of sand in concrete production. Such as include a comparison of the cost of sand and crushing plastics, with provision of large areas of land disposal. Several factors must be considered.
2. The workability of concrete that contains plastics need further attention. Improving concrete workability is expected to enhance many properties. Admixtures such as super plasticisers may be used but their influence on the mechanical properties of concrete have to be considered.
3. Further studies should be conducted on other sizes and types of recycled plastics.
4. Further studies should aim to improve the compressive strength on which many concrete properties are based.

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Appendix

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In this table, a summary of some previous studies, including replacement percentages, quantities of materials, water-cement ratios used, and their effects on the fresh and hardened properties of concrete is given.

Refer.	Replacement ratio %	Fresh and hard Properties	Remark
(Abdel Moti, H. M., and Mustafa, M. A., 2019).	1.M1=0% reference mix 2.M2=5% polypropylene (PP) recycled plastic from sand 3.M3=10% polypropylene (PP) recycled plastic from sand	1-The slump values for substitutes percentages tend to increase by 9.09% and 18.18% for substitutes 5% (M2) and 10% (M3) (depending on sand volume) compared to the control mix, respectively. 2- For the fresh density, the 5% replacement showed an increase of 0.134% compared to the control mix, which is a very slight increase, and the uneven distribution may be the reason for this result. But the 10% decreased by 4.095% compared to the control mix. The variation between the sand and the plastic aggregate is the main contributor to this reduction. 3- The dry density for both (7 and 28) days of cured samples tends to be lower than the control mix. The difference in percentage between plastic pellets and sand density is 69.5%, which explains the lower weight of concrete mixes containing 5% and 10% PP pellets. 4- Compressive strength for seven days of the cured Sample decrease by 18.5%and 9.42% respectively when replaced 5% and 10% from the fine aggregate. The 5% might have encountered some unnoticeable problems while mixing the (PP) pellets in the concrete mix and The compressive strength decreased for (28) days by 15.08% and (12.72) % for (5)% and (10)%, respectively. 5- The splitting tensile strength reduced by 18.15% and 14.03% for the 5% (M2) and 10% (M3) respectively compared to the control mix (M1). For the 5% and 10% of	1-Using cement content 375 Kg/m^3 2-Using coarse aggregate content 1145 Kg/m^3 with a maximum size of 20 mm 3- Using fine aggregate content (700,665 and 630) Kg/m^3 for (M1,M2 and M3), respectively 4-water content 180 Kg/m^3 (w/c = 0.47)

		the control mix. This may be due to the weak bond between the cement paste and the polypropylene (PP) surface. 6- The flexural strength increased by 8.33% and 19.44% for the substitutes 5% and 10%, respectively, compared to the control mix since the polypropylene (PP) pellets have higher bending resistance than the sand.	5- Using polypropylene (PP) content (55and 70) Kg/m^3 For (M1and M2), respectively.
(Almeshal, I., et al., 2020)	PET waste plastic replacement of fine aggregate by (10, 20, 30, 40, and 50)%	1- The Slump values decrease by (12, 50, and 88)% for (10, 30, and 50)% of PET replacement, respectively. 2-Compressive strength decreased by (1.2, 4.2, 31, 60 and 90.6) % for (10, 20, 30, 40, and 50) % of PET replacement respectively. 3- Tensile and flexural strengths reduced by (10.5–85.5)% and (2.4-84.2)% , respectively for PET (10–50)% replacement	1-cement content $370kg/m^3$ 2- water cement ratio 0.54
(Arivalagan, S., 2020).	1-reference mix (S1) 2- S2, S3, and S4 replacement of coarse aggregate by (10, 20, and 30)%, respectively.	1- The slump values of concrete mixture was reduced when increasing e-waste plastic after 10% in concrete where S1= 90 mm ,S2 =110 mm ,S3= 100 mm and S4 = 93 mm 2- The compressive strength was increased (20) % e-waste replacement at (7,14 and 28) days, but the compressive strength reduction to (30)% replacement of e-plastic. The poor bond strength of Electronic plastic led to this reduction. The maximum compressive strength at 28 days reached to 37Mpa for 20% replacement 3-The maximum split tensile strength at 28 days was reached to 5.5 MPa for 20% replacement but decrease to 3.75 at 30% replacement. weaker bonding between PVC and cement particles lead to this reduction 4- The flexural strength increase for 20% replacement at 28 days but reduced for (30)% replacement weaker bonding	1-Cement content 390kg/m3 2- Fine aggregate content 675 kg/m^3 3-Coarse aggregate content (S1=1150,S2 =1050, S3=850, and S4 = 650) kg/m^3 4- e-plastic content (30, 55, and 85) kg/m^3 for S2, S3, and S4, respectively

		between **PVC** and cement particles lead to this reduction	5- w/c ratio 0.45
(Rai, B. et al., 2012).	Plastic pallets replacement of fine aggregate by (5,10, and 15)%	1-Fresh density decrease by 5%, 8.7%, and 10.75% for 5%, 10%, and 15%, respectively, 2- Dry density of concrete containing plastic decreases with increasing the plastic replacement ratios (5, 10, and 15) %, respectively, where the density of concrete reached 2225 kg / m^3 at a replacement 15%. 3- The Slump values decrease by (72, 50, 39, and 26) mm for (5, 10, and 15) % of plastic pallets replacement, respectively. 4- Values of Compressive strength are (43, 41, 39, and 36) MPa for (5, 10, and 15) %of plastic pallets replacement, respectively.	1-Cement content 423 kg/m3 2- Fine aggregate content 469 kg/m^3 3-Coarse aggregate content 1282 kg/m^3 4- w/c ratio 0.44
(Nur Liza, R et al., 2013).	High density polyethylene waste (HDPE) was used in the concrete mixture with proportions of 10, 20, and 30%	The compressive strength at the age of 28 days decreased by 6.28, 19, and 35.77 % for mixtures containing HDPE proportions of 10, 20, and 30 %, respectively. The reason for the decrease in the compressive strength when increasing the proportions of plastic replacement is due to the weak bonding strength between the cement paste and the plastic (HDPE)	
(Jaivignesh, B., and **Sofi, A. 2017)**	plastic waste replacement of fine aggregate by (10, 15, and 20)% and replacement of coarse aggregate by (15, 20, and 25)%	1-Compressive strength decreased by (9.5, 13.77and 17.4) % for (10PF and 15PC, 15PF and 20PC, 20PF and 25PC) % of plastic waste replacement respectively at 28. 2-Split Tensile Strength decreased by (19.8, 14.35and 24.25) % for (10PF and 15PC, 15PF and 20PC, 20PF and 25PC) % of plastic waste replacement respectively at 28. 3-Flexural Strength decreased by (17.77, 25.18and 33.82) % for (10PF and 15PC,	1-Cement content 395 kg/m^3 2- Fine aggregate content 706 kg/m^3 3-Coarse aggregate

	PF= plastic fine aggregate. PC= Plastic Coarse aggregate.	15PF and 20PC, 20PF and 25PC) % of plastic waste replacement respectively at 28.	content 1151 kg/m^3 4- w/c ratio 0.5