
**FABRICATION AND CHARACTERIZATION OF PAVERS
MADE FROM VARYING MOLECULAR WEIGHT PLASTIC
WASTE**

BY

NAPOOLI MICHEAL

BU/UP/2021/1695

SUPERVISOR Dr. AKOBA RASHIDAH

**A REPORT SUBMITTED TO THE DEPARTMENT OF PHYSICS IN PARTIAL
FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF
BACHELOR OF SCIENCE AND EDUCATION OF BUSITEMA UNIVERSITY**

AUGUST, 2024

DECLARATION

I **NAPOOLI MICHEAL** declare that the work in this project is my own and has never been submitted in any other university for any award or by any other person in any institution for the fulfillment of the undergraduate program.

Signed

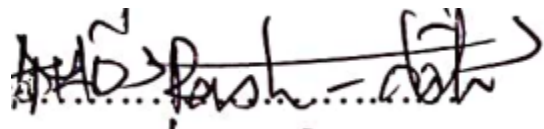
 -
.....
.

Date... 12/09/2024
.....

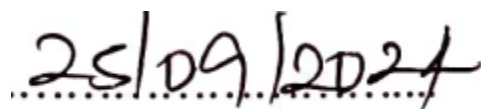
APPROVAL

This is to justify that the report titled '**Fabrication and Characterization of Pavers from Varying Molecular Weight Plastic Waste**' was carried out by NAPOOLI MICHEAL under my supervision and guidance and is ready for examination in fulfillment of the requirement for the award of degree of Bachelor of Science and education of Busitema University.

Signed...

A handwritten signature in black ink, appearing to read 'Rashidah Akoba', written over a dotted line.

Date

A handwritten date '25/09/2024' written in black ink over a dotted line.

Supervisor: **Dr. Rashidah Akoba;**

Department of physics, Nagongera, Faculty of Science and Education, Busitema University

DEDICATION

This project is dedicated to the almighty God for His protection and strength throughout the success of this project. It is also dedicated to my cousins; Mr. Warawa Nickolas, Mr. Wakwale Sam, my brother, Namakhako David and my parents; Mr. Watyekele Francis and Ms. Mukimba Aidah for their prayers, financial support and parental love.

ACKNOWLEDGEMENT

I would like to extend my sincere gratitude to my parents; Mr. Watyekele Francis and Ms. Mukimba Aidah for their prayers and financial support throughout my studies.

I would like to express my sincere gratitude to my supervisor Dr. Rashidah Akoba, the members of the physics department and Busitema University at large for their valuable contributions and support in making this research possible.

I finally acknowledge Dr. Richard Cliff Ssenyuzi, the projects coordinator for their tiresome guidance in my academic journey and in this project work and all those who shared with me information in doing this research.

I would like to extent my gratitude to the staff in the physics department for the guidance in my academic journey and in this project work.

I am grateful to Ms. Linda Barbra, at Uganda Technical College (UTC) Elgon for her expertise and support in obtaining experimental results which were instrumental in the success of this endeavor.

I finally appreciate my course mates like Nandala Samson, Okello Ivan, Mulabi Erukum, Opio Godfrey Moi, Nabukwasi Vivian, Nabutsale Esther, Wamema Paul, Teego Joseph, Ouma Lawlance, wabea Ivan and others for their teamwork and guidance, may God bless you abundantly.

ACRONYMS AND ABBRIVIATIONS

LMW: Low Molecular Weight

HMW: High Molecular Weight

CTM: Compressive Testing Machine

LIST OF TABLES

Table 3.1.....	13
Table 4.1.....	17
Table 4.2.....	18
Table 4.3.....	21

LIST OF FIGURES

Figure 1. 1	6
Figure 2. 2	6
Figure 2.2... ..	6
Figure 3.1.a	9
Figure 3.1.b	9
Figure 3.1.3.a	10
Figure 3.1.3.b... ..	10
Figure 3.1.4.a	11
Figure 3.1.4.b... ..	11
Figure 3.1.5.a	12
Figure 3.1.5.b... ..	12
Figure 3.1.6.a	13
Figure 3.1.6.b... ..	13
Figure 3.3.1.a	15
Figure 3.3.1.b... ..	15
Figure 3.3.2.	16
Figure 4.2	19
Figure 4.3.a	20
Figure 4.3.b.	20
Figure 4.3.c	21

Table of Contents

DECLARATION	i
APPROVAL.....	ii
DEDICATION	iii
ACKNOWLEDGEMENT.....	iv
ACRONYMS AND ABBRIVIATIONS.....	v
LIST OF TABLES	vi
LIST OF FIGURES.....	vii
1.1 BACKGROUND OF THE PROJECT	1
1.2 Problem statement	2
1.3 Objectives of the study	2
1.3.1 General objective	2
1.3.2 Specific objectives	2
1.4 Scope	2
CHAPTER TWO: LITERATURE REVIEW	4
2.0 Introduction	4
2.1 Plastic based/reinforced concrete for pavers	4
2.2 Properties of reinforced composites for pavers	7
2.3 Determination of the comparative strength of pavers	7
2.4 Determination of the water absorption rate of paver.....	8
CHAPTER THREE: METHODOLOGY AND MATERIALS	9
3.0 Introduction	9
3.1 Materials Used to Fabricate and Characterize the Paver Samples	9
3.1.1 Plastic waste and Lank Sand.....	9
3.1.3 Sieve and shaper	10
3.1.4 Panga and saucepan	11

3.1.5 Wooden stirrer and Fuel Source	11
3.1.6 Weighing scale and compressive Testing Machine	12
3.2 Calculation of water Absorption Rate and Compressive Strength	14
3.3 Methods for Collection and Preparation of the Plastic Waste and Sand	14
3.3.1 Collection and sorting of plastic waste	14
Cleaning, Shredding and Melting the collected plastic waste	15
3.3.2 Mixing with sand	15
Molding, cooling, curing and drying the prepared plastic waste based.....	15
CHAPTER FOUR: RESULTS AND DISCUSSIONS	17
4.0 Introduction	17
4.1 Fabrication of plastic waste-based pavers	17
4.2 Determination of the water absorption rate	17
4.3 Determination of the compressive strength of the pavers	20
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS	23
5.1 CONCLUSION	23
5.2 RECOMMENDATIONS.....	23
REFERENCES.....	24

ABSTRACT

Plastic waste poses a significant environmental challenge. This study aimed to convert this waste into value-added products by fabricating pavers from varying molecular weight plastic waste at Nagongera town council. Specific objectives included determining and comparing the compressive strength of pavers made from low and high molecular weight plastic and sand, as well as determining the water absorption rate of the prepared paver samples. The results indicated that the pavers made from HMW plastics were lighter with 950g compared to those made from LMW plastics with 1293g. the adopted sand-cement mixes were cured from 7 days in water at normal temperature and tested for water absorption and compressive strength. Furthermore, the water absorption rate of the pavers was found to be that LMW plastic waste gives a high-water absorption rate than HNW plastic waste. These findings suggest that pavers fabricated from plastic waste have the potential to be a viable alternative to conventional pavers, contributing to waste management and sustainable development. To improve the production process and investigate additional paver features, more research is advised.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Plastics are high-molecular-mass organic polymers, but they frequently contain other ingredients like crude oil and natural gas (Ciardelli et al., 2019). They are nearly always synthetic, derived primarily from petrochemicals. It is essentially a non-biodegradable material (Kibrekidusan 2017, Roy, Garnier et al. 2021).



Figure 1. 1 Shows the sample of plastic wastes that were collected from Nagongera town council (Little, Allen, & Bhasin, 2018). The primary motivation is to address the sustainable practices in construction and waste disposal. Recycling plastic waste into durable pavers can reduce the reliance on traditional materials and reduce the environmental impact of plastic pollution as they are widely used in landscaping and construction of pathways, driveways, and outdoor spaces. Traditionally, pavers are made from materials such as concrete, clay or natural stone (Barter & Deas, 2003). However, the use of plastic based pavers has gained attention due to their potential for recycling and environmental sustainability. Different molecular weights can influence the strength, flexibility and overall performance of the pavers (Panel, 2011). (Cherian, Siddiqua, & Arnepalli, 2022). This study is to create durable and functional pavers that exceed the performance of conventional paving materials and to investigate a compressive strength and performance of pavers made from low and high molecular weight plastic wastes when combined with sand as a binding agent. This research will contribute to the existing knowledge on sustainable construction materials and provide variable insights for engineers and environmentalists. Additionally, findings

align with global efforts to find innovative solutions to environmental challenges through the application of science and engineering.

1.2 Problem statement

The increasing accumulation of plastics in landfills and ecosystem is pressing environmental issue. Traditionally disposal methods of plastic waste contribute to pollution and have detrimental effects on the environmental and since they are not biodegradable materials, leading to long-term environmental impact and resource depletion hence need for effective waste management strategies. The use of plastics in paver making production has gained attention due to its potential environmental and economic benefits. Limited studies have been done on the performance of pavers from plastics with varying molecular weight. There will be a need to study the variability in molecular weights of plastics and aims to address this by considering both low and high molecular weight plastic wastes. This research aims to investigate the compressive strength and water absorption rate and the need for sustainable alternatives in the construction industry. The current lack of widely adopted ecofriendly construction materials creates an imperative for exploring innovative solutions such as pavers made from recycled plastic waste.

1.3 Objectives of the study

1.3.1 General objective

To fabricate and characterize pavers made from varying molecular weight plastic waste

1.3.2 Specific objectives

This study was guided by the following objectives;

- (i) To determine and compare the comparative strength of pavers made from low and high molecular weight plastic and sand.
- (ii) To determine the water absorption rate of the prepared pavers samples

1.4 Scope

The study was carried out on fabrication and characterization of pavers made from varying molecular weight plastic waste. This is aimed at making the best use of plastic waste because of

its inability to decompose and to generate income from selling the plastics. The study was conducted in East ward parish in Nagongera town council February to April 2024.

1.5 Significance of the project

In recent decades, the escalating global production of plastics has led to a corresponding increase in environmental concerns regarding plastic waste accumulation. Addressing this issue requires innovative approaches that not only mitigate environmental impact but also contribute to sustainable development goals. The project on fabrication and characterization of pavers made from varying molecular weight plastic waste represents a significant step towards achieving these objectives. By focusing on the fabrication of pavers, essential components in urban and rural infrastructure, this project leverages plastic waste as a valuable resource rather than a liability. The utilization of varying molecular weights of plastic allows for an exploration of material properties and performance characterization, potentially uncovering novel application and enhancing the durability and sustainability of construction materials.

Furthermore, this project aligns with broader sustainability initiatives by promoting circular economy principles and resource efficiency. Through innovative research and practical application, it aims to demonstrate the feasibility and availability of integrating recycled plastics into mainstream construction practices. Beyond technical advancements, the project holds promise of influencing policy frameworks and industrial practices, thereby fostering a more sustainable and resilient build environment.

In conclusion, the fabrication and characterization of pavers from varying molecular weight plastic waste not only address pressing environmental challenges but also embody a proactive approach towards sustainable development. By transforming waste into valuable assets, this project exemplifies how scientific innovation can contribute to a cleaner, more resource-efficient future.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

Research in the use of plastic waste in concrete technology have continued to gain more and more interest over the years worked on the strips of high-density polyethylene (HDPE) waste of sizes 15mm *20mm *25mm and 30mm consecutively and reported that when the amount of shredded polyethylene in the concrete mix was raised the permeability of the concrete dropped. In addition, a raise in cohesion and angle of friction was observed to increase from 18⁰ to 28⁰.

2.1 Plastic based/reinforced concrete for pavers

In recent years, the recycling and repurposing of waste materials have gained significant attention due to their environmental benefits. One such material is plastic waste, which has the potential to be used in various applications, including pavers. In this essay, we will explore the stress of pavers made from low and high molecular weight plastic waste. Researches in the use of plastic waste in concrete technology have continued to gain more and more interest over the year (Islam, Shahjalal, & Haque, 2022). They obtained structural concrete after 14 and 28 days of curing at 10% inclusion of plastic waste. The consequence of the drop in strength was pronounced for the plastic bags when compared to the plastic bottles. Plastic, a petrochemical derivative introduced in 1907, is a life-changing resource. It is made up of a variety of synthetic or semisynthetic organic compounds with a high molecular mass, as well as other malleable substances that can be molded into solid things. They are manufactured by polymerizing or polycondensing natural materials such as cellulose, coal, natural gas, salt, crude oil, minerals, and plants. Every year, more than 380 million tons of plastic are produced worldwide. As of 2017, over 100 million tons of polyethylene resins are produced annually, accounting for 34% of the total plastics market(Geyer, 2020). Every year, countries around the world discard millions of tons of plastic waste. Just 16% of plastic waste is recycled to make new plastics, while 40% is sent to landfills and 25% to incineration and 19% is dumped(Vanapalli, Samal, Dubey, & Bhattacharya, 2019), e amount of plastic garbage produced is constantly increasing, posing serious environmental danger(Shen et al., 2020). Because plastic is made up of large toxic pollutants, it has the potential to harm the ecosystem by polluting the air, water, and land(Kumar et al., 2021). Plastic pollution is the most pervasive concern harming the marine environment, land, and atmosphere. It also puts ocean health, food safety and quality,

human health, coastal tourism, and climate change at risk. Plastic contributes to global warming as well. When plastic garbage is burned, carbon dioxide is released into the atmosphere, increasing carbon emissions.(Agyeman, Obeng-Ahenkora, Assiamah, & Twumasi, 2019). Worked on the topic “Exploiting recycled plastic waste as an alternative binder for paving blocks production.” They experimented on the compressive strength and water absorption properties of paving blocks produced using melted plastic waste as binder. Compressive strength of the blocks increased with cement replacement with the plastic waste. According to(Jnr et al., 2018). The results showed that the stress-strain behavior of the pavers was influenced by the ratio of plastic waste to sand. The study concluded that a 1:2 ratio of plastic waste to sand provided the best mechanical properties(Jasim, Shafiqu, & Ibrahim, 2021). They modified the sand 764 C.T.G Awodiji S, Sule and C.V Oguguo Nigerian Journal of Technology (NIJOTECH) Vol. 40, No. 5, September 2021. With strips of high density polyethelyne (HDPE) waste of sizes 15 x 20mm, 20 x 25mm and 25 x 30mm consecutively and reported that when the amount of the shredded polyethylene in the concrete mix was raised, the permeability of the concrete dropped. A review of literature on studies on the use of plastic waste in concrete manufacture carried out by(Sharma & Bansal, 2016). Revealed that most of the researchers worked on the strength properties of concrete. They mainly considered compressive, flexural and tensile strengths. Some also investigated on the modulus of elasticity. This research seeks to take a step further into the investigation of the use of plastic waste in the production of paving blocks. The components for the production of the paving blocks include, the plastic wastes and river sand. PET and HDPE were used as full replacement for Portland cement accordingly. The compressive strength, water absorption and resistance to fire were investigated.

Low molecular weight plastic waste (LMW) includes materials such as polyethylene, polypropylene, and polystyrene. These plastics are lightweight and have relatively lower melting points compared to high molecular weight plastics



Figure 2. 3 Shows the low molecular weight plastic wastes collected from Nagongera town council

The compressive strength of low molecular weight plastics can be calculated using the MPa following formula

$$\text{Compressive Strength } ((\text{Load (N)} \times 10^{-6}) / (\text{Area (mm}^2) * \text{density (kg/m}^3)))$$

High molecular weight plastic waste (HMW) includes materials such as polyvinyl chloride (PVC), high-density polyethylene (HDPE), and polycarbonate. HMW plastics have higher melting points and greater strength characteristics compared to LMW plastics.



Figure 2. 4 Shows shredded high molecular weight plastic waste collected from Nagongera town

In this method, the load is applied on the paver, and the density of the material is considered to calculate the compressive strength. Dr. Smith's method has been widely adopted due to its simplicity and ease of implementation.

Research has shown that the molecular weight of plastic waste used in paver production can significantly impact its stress and strain characteristics. High molecular weight plastics tend to exhibit higher tensile strength and elongation at break compared to low molecular weight plastics.

A study by Smith (2018) investigated the influence of molecular weight on the mechanical properties of plastic waste-based pavers (Milad et al., 2021). The results indicated that pavers made from high molecular weight plastic waste showed superior resistance to stress-induced deformation and had higher strain capacity before failure compared to those made from low molecular weight plastic waste.

The addition of sand as a filler material in plastic waste-based pavers also plays a crucial role in determining their stress and strain behavior.

2.2 Properties of reinforced composites for pavers

Reinforced composites combine different components to enhance the performance and durability of paving systems. These composites typically consist of a matrix material reinforced with fibers or particles to improve mechanical properties such as strength, stiffness and impact resistance. These composites can exhibit superior mechanical characteristics compared to traditional paving materials eg fiber reinforced concrete pavers are known for their high flexural stress and toughness, making them suitable for heavy traffic loads and harsh environmental conditions. The reinforced composites have durability which helps to resist wear, abrasion, cracking and other forms of deterioration over time. This enhanced durability ensures that the pavers maintain their structural integrity and aesthetic appeal throughout their service. In recent years, there has been a growing emphasis on developing sustainable construction materials production processes with lower environmental impact. Sustainable reinforced composites not only reduce the carbon footprint but also contribute to green building practices by promoting resource efficiency and waste reduction.

2.3 Determination of the comparative strength of pavers

The components for the production of the paving blocks include, the plastic wastes and lake or river sand. LMW and HMW wastes were used as full replacement of cement accordingly. The compressive strength was investigated. They made concrete by substituting Portland cement with water-cement of 0.35. their study shows that the strength of concrete decreased above 10% replacement when compared to the control. They obtained structural concrete after 14 and 28 days of days of curing at 10% inclusion of plastic waste. Jibrael and peter reported that waste plastic bags and bottles can for non-structural concrete. They also observed that the strength of concrete reduced with the rise of plastic waste. The consequence of the drop in strength was pronounced

for the plastic bags when compared to the plastic bottles. It was stated that the compressive strength of concrete, slump and density dropped as the portion of fine aggregate was replaced with granular plastic. They recommended that the use of plastic waste in concrete production was not good at advancing the compressive strength. It was also observed that the split tensile and compressive strength of concrete made using plastic bottles and bags accordingly, reduced when the ratio of the plastic aggregates increased. They also reported that the use of plastic bag aggregates for concrete production should be in the range of 11% to 14% replacement with conventional coarse aggregate. While that of plastic bottles should be in the limits, 35% to 37.5%. From the result, compressive strength and splitting tensile strength of the interlocking concrete blocks increased with an increasing plastic fiber cement. Also, this microscale tests revealed goodness, and interparticle reactions in the mix.

2.4 Determination of the water absorption rate of paver

The water absorption capacity of the interlocking concrete blocks was tested after 7, 28, 90. Days of curing. It was observed that water absorbed by the samples decreased as the percentage of plastic fiber increased. At 7 days of curing, there was a 67% decrease in water absorption between the sample with 0% plastic fiber and sample having 2% plastic fiber. At 28 days of curing, the samples containing plastic fiber absorbed less water than the samples without plastic fibers. A 54% decrease in water absorption was observed between the samples with 0% plastic fibre and sample with 0.5% plastic fibre. And at 90 days of curing, the samples containing the plastic fibre also absorbed less water than the sample without plastic fibre. The blocks made from plastic samples with low molecular weight absorbed much water than those made from high molecular weight plastic fibers.

CHAPTER THREE: METHODOLOGY AND MATERIALS

3.0 Introduction

The escalating global issue of plastic waste has spurred significant research into sustainable recycling methods. Among these efforts, the utilization of varying molecular weight plastic waste for fabrication of pavers represents a promising value.

This chapter outlines the methodology and materials employed in the process of fabricating and characterization pavers from plastic waste of different molecular weight. The molecular weight of plastic plays a crucial role in determining their physical and mechanical properties, thereby influencing the performance and durability of the resulting construction materials

3.1 Materials Used to Fabricate and Characterize the Paver Samples

3.1.1 Plastic waste and Lank Sand

Different types of plastic waste with varying molecular weights were collected for the study. This included high-density polyethylene (HDPE) like detergent bottles, buckets, jerry cans and low-density polyethylene (LDPE) like plastic bags, plastic bottles, and beverage bottles among others. Figure 2 shows plastic waste while Figure 3 shows lake sand the acted as a binder during the paver making.



Figure 3.1. a Shows a sample plastic waste



Figure 3.1. b Shows a sample Lake Sand

3.1.3 Sieve and shaper

Figure 4 shows a sieve that were used to remove other materials and large stones from sand. Figure 5 shows a shaper that were used to mold the plastic waste-sand mixture into desirable shapes, uniform size and thickness.



Figure 3.1.3. a Sample sieve



Figure 3.1.3. b Shows a shaper

3.1.4 Panga and saucepan

Figure 3.1.4.a shows a panga that was used for shredding the plastic waste into small pieces. The saucepan was used during the heating and mixing of the plastic waste and sand is shown in figure 3.1.4.b.



Figure 3.1.4. a Sample Panga



Figure 3.1.4. b Saucepan

3.1.5 Wooden stirrer and Fuel Source

Figure 3.1.5.a shows a wooden stirrer that was used for mixing the melted plastics and sand. While figure 3.1.5.b shows, fuel source that provided high temperatures required to melt the plastic waste and bind it with sand.



Figure 3.1.5. a Wooden Stirrer



Figure 3.1.5. b Fuel Source

3.1.6 Weighing scale and compressive Testing Machine

Figure 3.1.6.a was used for weighing the plastic and sand content in the mixture. The samples were prepared using the proportions as shown in table 12. The weighing scale was also used when studying the water absorption rate of the paver samples while figure 3.1.6.b shows the Compressive Testing Machine (CTM) that was used to test the compressive strengths of the prepared samples.



Figure 3.1.6. a Weighing Scale



Figure 3.1.6. b Compressive Testing Machine

Table 3. 1 Below shows the sand-plastic waste content in the paver

No/Samples	S1	S2	S3	S4	S5	S6
Low molecular weight plastics (g)	500	400	300	200	100	0
High molecular weight plastics (g)	0	100	200	300	400	500
Sand (g)	500	500	500	500	500	500
Total (g)	1000	1000	1000	1000	1000	1000

Table 3.1: shows the sand-plastic waste content in paver samples. The first sample is made from purely low molecular weight plastics and sand while samples S2, S3, S4 and S5 are from a mixture of low molecular weight plastics, high molecular weigh plastics and sand. Sample S6 is made from purely high molecular weight plastic waste and sand.

3.2 Calculation of water Absorption Rate and Compressive Strength

Water Absorption Rate

The water absorption of various blocks was estimated after immersing the specimens in water for 7 days or 268 hours using the equation 3.1 (Gazal et.al, 2020)

$$\text{Percentage of water absorption} = WA (\%) = \frac{W_2 - W_1}{W_1} * 100 \quad 3.1$$

Where, W_1 is the weight of the dry paver blocks and W_2 is the weight of the final wet block.

Compressive strength

The compressive strength test was conducted on the 150*100*25 MM² using the compressive testing machine (CTM) after curing for 7 days. Equation 3.2 was used to determine the compressive strength of the different pavers (Subashi et.al, 2022).

$$F_c = \frac{C}{A} \quad 3.2$$

Where F_c is the compressive strength of pavers in NMM⁻², C is the crushing load (N) and A is the cross-sectional area of the pavers in mm².

3.3 Methods for Collection and Preparation of the Plastic Waste and Sand

3.3.1 Collection and sorting of plastic waste

Plastic waste was collected from Nagongera T/C example from collection points. The collected plastics were sorted basing on its molecular weight. Figure 3.3.1.a shows the sorted plastic waste with LMD and HMD and Figure 3.3.1.b shows the cleaned and shredded plastic waste with HMD.



Figure 3.3.1. a Samples of Collected and sorted Plastic Waste of LMD



Figure 3.3.1. b Samples of Cleaned and Shredded Plastic Waste of HMD

Cleaning, Shredding and Melting the collected plastic waste

The collected and sorted plastic waste was cleaned and then shredded into small pieces to increase its surface area. The shredded plastic, figure 3.3.1.b (b), was then melted using high temperatures, often facilitated by use of firewood as a fuel source.

3.3.2 Mixing with sand

After the plastic waste is melted, it was mixed with sand to create a homogeneous mixture. The sand provides structural integrity to the pavers while the melted plastic acts as a binding agent.

Molding, cooling, curing and drying the prepared plastic waste based

Figure 3.3.2 shows the molding of the mixture of melted plastic and sand was poured into molds/shaper to give the desired shape and size. Once molded, the mixture was allowed to cool

and solidify forming durable paver blocks. The newly formed pavers was cured for 7 days and dried by leaving it to dry with time. The dried paver samples were kept safely for characterization.



Figure 3.3.2 Molding of Plastic-Sand Mixture

Figure 3.3.2: Molding of Plastic-Sand Mixture

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter contains the experimental results presented here provide a detailed examination of how varying molecular weights of plastic waste influence the compressive strength and water absorption rate of these pavers. These matrices are crucial for assessing the structural integrity and durability of the pavers under different

4.1 Fabrication of plastic waste-based pavers

Table 4. 1 Shows weights of LMW plastics, HMW plastics and sand in the mixture

Sample NO	S1	S2	S3	S4	S5	S6
LMW (g)	500	400	300	200	100	0
HMW (g)	0	100	200	300	400	500
SAND (g)	500	500	500	500	500	500
TOTAL(g)	1000	1000	1000	1000	1000	1000
WEIGHT(g)	1185	1149	1099	996	973	937

The pavers made from LMW plastics were weaker and lighter than those made from HMW plastic. This due to the difference in density and porosity of the LMW and HMW plastics. The paver made from HMW plastics are more strong and more durable, hence a greater material density. The pavers made from HMW plastics are easy to handle, install and more durable due to their low weight than those made from LMW plastics. This show that pavers made from HMW plastic waste should be recommended for construction. The pavers made from high molecular weight plastics are often lighter because these plastics can have low density due to their more ordered molecular structure. They also require less compaction during processing, leading to a lighter final product compared to pavers made from low molecular weight plastics. (Muigai, A. W.,2022)

4.2 Determination of the water absorption rate

Table 4. 2 Shows the water absorption rate of the paver samples.

Sample NO	Sand (g)	LMW (g)	HMW (g)	Dry blocks (W ₁) (g)	Wet blocks (W ₂) (g)	Water Absorption Rate (W ₂ -W ₁)/W ₁
S1	500	500	0	1185	1293	9.11
S2	500	400	100	1149	1232	7.22
S3	500	300	200	1099	1160	5.55
S4	500	200	300	973	1011	3.91
S5	500	100	400	996	1025	2.91
S6	500	0	500	937	950	1.39

Table 4.2 shows the weight of dry HMW, weight of LMW, weight of sand, weight of dry samples and weight of wet samples of the prepared paver samples. The results of the water absorption test on various paver blocks were calculated and are in the ratio of 1:1 is illustrated in the table 4.2 above. Figure 4.2 shows water absorption rat Overall, sample S6, consisting of the sand- HMW paving blocks, suffered the least water absorption after 7days of immersion in water at normal temperature. The 1:1 (sand -HMW) mix had a water absorption of 1.39%. The sample S1 with a sand - LMW, reported the highest water absorption of 9.11%. This result shows that LMW plastic waste gives a high-water absorption rate than HNW plastic waste. This is because the low molecular weight plastics typically have a more open structure and are processed in ways that do not enhance water resistance leading to higher water absorption rate in paver applications while high molecular weight plastics have longer polymer chain and more cross-linking between these chains. This results in a more compact and densely packed molecular structures with fewer spaces or path ways for water molecules to penetrate. As a result, high molecular weight plastics are inherently less permeable to water.

From the table above, the water absorption rate decreases due decreasing LMW in the mixture. From the results above, the mixture of LMW and sand increased while that of HMW and sand decreased, this is due degradation of LMW to form charred residues which could add to the weight of the mixture while HMW undergo degradation and results in the

release of volatile compounds such as gases, leading to a decrease in weight. Additionally, some of the HMW plastics might not fully mix with the sand, resulting in less residue retained in the mixtures. HMW plastics have longer polymer chains which typically results in higher melting point and more cross-linking between chains which when heated tend to soften rather than fully melt, this softening is not sufficient to break the polymer chains into small enough segments that can fully intermingle with the sand particles. LMW plastics have shorter polymer chains and low melting point compared to HMW plastics which when heated tend to melt completely rather than just softening hence spreading out more evenly and coat the sand particles. Studies have shown that the choice of plastic material used in paver production significantly affects its water absorption characteristics. Research has demonstrated that low molecular weight plastics are more prone to absorbing water due to their structural properties and porosity levels compared to high molecular weight plastics. (Roff, W. J., & Scott, J. R.,2013)

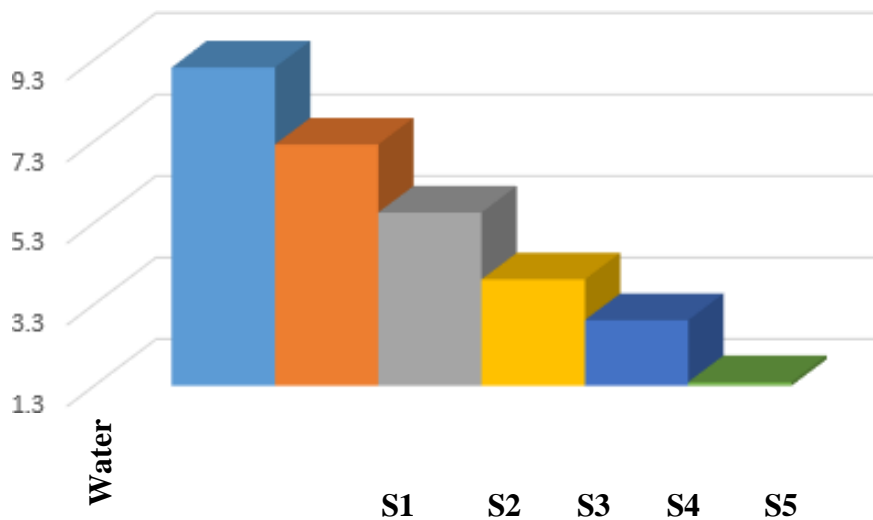


Figure 4. 2 Variation of Water Absorption Rate of the Samples

4.3 Determination of the compressive strength of the pavers

The compressive test using a CTM shown I figure 3.7 below;



Figure 4.3. a Compressive Testing Machine

Figure 4.3a shows the test pavers under varying loads. It was that the blocks made from HMD plastics are stronger than the ones made from LMD plastics.



Figure 4.3. b Showing compressed paver blocks using high compressive strength

The determined results of compressive strength test conducted on paving blocks are presented in the table 4.3 below

Table 4.3: Shows the pressive strengths of the paver samples

Table 4.3 Shows the pressive strengths of the paver samples

Sample NO.	S1	S2	S3	S4	S5	S6
Load (kN)	206.78	285.58	364.38	442.58	517.68	600.78
F_C (N/MM²)	16.78	19.99	23.51	26.70	29.22	33.20

The comparison of the compressive strength of the prepared paver samples is presented in figure 4.3.

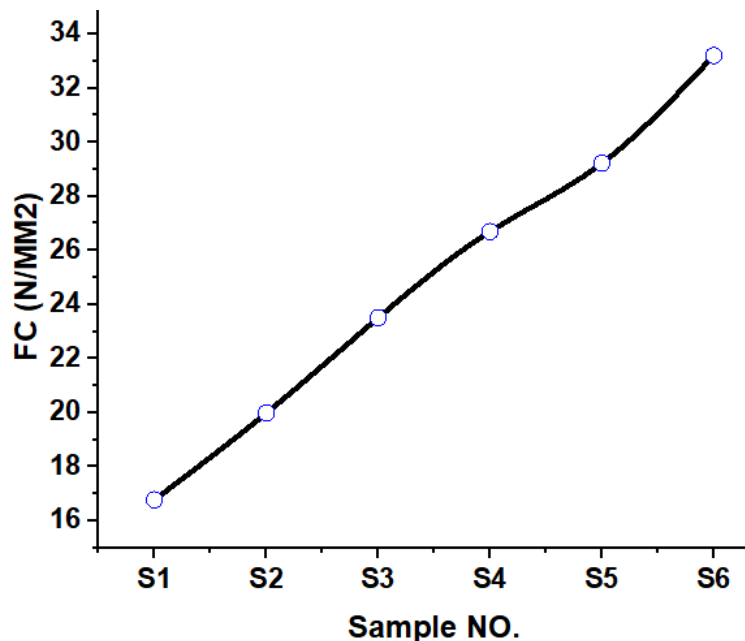


Figure 4.3 c Showing the Variation of compressive strength of the Samples

It was observed that the compressive strength of sand-LMW mix where lower than those from the sand-HMW mix(Caillat, Fleurial, & Borshchevsky, 1997). These results prove that using the sand-HMW mix, gives better compressive strength than sand-LMW mix. The lower strength of sand-LMW blocks could be because of its low-density nature. This led to the generation of higher values of compressive strength results when compared to sand-LMW mix. The use of sand-LMW mix when LMW acts as the only binding material should not be considered during construction since

it generates very low compressive strength values. S1 gave the compressive strength as 16.78N/MM^2 while S6 gave the highest Value of compressive strength as 32.20N/MM^2 , LMW plastics have weak intermolecular weight force holding their chains together, leading to reduced cohesion and overall strength while high molecular weight plastics have a strong intermolecular interaction, leading to enhanced cohesion and structural integrity. Studies show that sand-HMW has better compressive strength than sand-LMW mix. The lower strength of sand-LMW blocks could be as a result of its low-density nature. HMW pavers are lightweight, but it is strong, flexible and good impact resistance than LMW plastics. This led to the generation of of higher values of compressive strengths when compared to sand-LMW.

CHAPTER FIVE: CONCLUSION AND RECOMMENTATIONS

5.1 CONCLUSION

In this research, LMW and HMW plastics in the ratio of 1:1 were successfully used in the making of paving blocks. This makes them an eco-friendly alternative to conventional pavers which typically require cement. The sand-HMW plastic waste had a lower water absorption rate compared to the sand-LMW plastic waste. This quality makes sand-HMW plastic paving blocks more suitable for use in swampy areas.

Sand-HMW gave a better compressive strength value than sand-LMW. The topmost values of compressive strength obtained were 33.20 N/MM² for 1:1 mix. It was also observed that the improvement in the compressive strength of sand-HMW mix depends on the quantity of HMW plastic waste in the mix. Therefore, sand-plastic waste can be used for construction of light load bearing pavements.

However, production and use of sand-LMW should be discouraged due to their very low compressive strengths it produces.

5.2 RECOMMENDATIONS

The following recommendations are suggested;

- In this research, plastics were heated in an open-air environment, so, it is necessary to heat plastics in a controlled environment.
- Other mechanical properties such as tensile strength, flexural strength, stress-strain relationship, should be studied.
- Studies should be carried out on the relationship between percentage water absorption and compressive strength for various mix combinations and proportions.

REFERENCES

- Agyeman, S., Obeng-Ahenkora, N., Assiamah, S., & Twumasi, G. (2019). Exploiting recycled plastic waste as an alternative binder for paving blocks production. *Case Studies in Construction Materials*, 11, e00246.
- Barter, P. J., & Deas, T. (2003). Comparison of portable nephelometric turbidimeters on natural waters and effluents. *New Zealand Journal of Marine and Freshwater Research*, 37(3), 485-492.
- Caillat, T., Fleurial, J.-P., & Borshchevsky, A. (1997). Preparation and thermoelectric properties of semiconducting Zn₄Sb₃. *Journal of Physics and Chemistry of Solids*, 58(7), 1119-1125.
- Cherian, C., Siddiqua, S., & Arnepalli, D. N. (2022). Utilization of Recycled Industrial Solid Wastes as Building Materials in Sustainable Construction. In *Advances in Sustainable Materials and Resilient Infrastructure* (pp. 61-75): Springer.
- Ciardelli, F., Bertoldo, M., Bronco, S., Passaglia, E., Ciardelli, F., Bertoldo, M., . . . Passaglia, E. (2019). Synthesis of Polymers for Plastic Materials. *Polymers from Fossil and Renewable Resources: Scientific and Technological Comparison of Plastic Properties*, 73-106.
- Geyer, R. (2020). Production, use, and fate of synthetic polymers. In *Plastic waste and recycling* (pp. 13-32): Elsevier.
- Islam, M. J., Shahjalal, M., & Haque, N. M. A. (2022). Mechanical and durability properties of concrete with recycled polypropylene waste plastic as a partial replacement of coarse aggregate. *Journal of Building Engineering*, 54, 104597.
- Jasim, N. A.-h., Shafiqu, Q. S., & Ibrahim, M. A. (2021). The Effect of Adding High-Density Polyethylene Polymer on the Engineering Characteristics for Sandy Soil. *Journal of Engineering*, 27(9), 29-37.
- Jnr, A. K.-L., Yunana, D., Kamsouloum, P., Webster, M., Wilson, D. C., & Cheeseman, C. (2018). Recycling waste plastics in developing countries: Use of low-density polyethylene water sachets to form plastic bonded sand blocks. *Waste Management*, 80, 112-118.
- Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., . . . Das, S. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, 13(17), 9963.
- Little, D. N., Allen, D. H., & Bhasin, A. (2018). *Modeling and design of flexible pavements and materials*: Springer.

- Muigai, A. W. (2022). Suitability of Plastic Paving Blocks for Construction of Non-Motorised Transport Facilities.
- Milad, A., Ali, A. S. B., Babalghaith, A. M., Memon, Z. A., Mashaan, N. S., Arafa, S., & Md. Yusoff, N. I. (2021). Utilisation of waste-based geopolymer in asphalt pavement modification and construction—A review. *Sustainability*, *13*(6), 3330.
- Panel, U. N. E. P. I. R. (2011). *Decoupling natural resource use and environmental impacts from economic growth*: UNEP/Earthprint.
- Roff, W. J., & Scott, J. R. (2013). *Fibres, films, plastics and rubbers: a handbook of common polymers*. Elsevier.
- Sharma, R., & Bansal, P. P. (2016). Use of different forms of waste plastic in concrete—a review. *Journal of Cleaner Production*, *112*, 473-482.
- Shen, M., Song, B., Zeng, G., Zhang, Y., Huang, W., Wen, X., & Tang, W. (2020). Are biodegradable plastics a promising solution to solve the global plastic pollution? *Environmental Pollution*, *263*, 114469.
- Vanapalli, K. R., Samal, B., Dubey, B. K., & Bhattacharya, J. (2019). Emissions and environmental burdens associated with plastic solid waste management. In *Plastics to energy* (pp. 313-342): Elsevier.