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Utilization of Sand Deposits in Various Areas in Pavement Blocks Production with Plastic Waste Binder: A Comparative Study in Bamenda City

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Abstract

This study investigates the use of plastics waste as a binder in pavement block production, combining it with various local sands and gravel. The discoveries of this study show that composites developed from Mbatu, Ndop and Wum sands display a Water Absorption Capacity (WAC) less than 6%, with Compressive Strength (CS) and Flexural Strength(FS) values between (17.2 – 20.7) MPa and (2.1 – 2.8) MPa respectively at 40% PET content which the composites can be used for outdoor space applications. The composites developed from Chomba, and Mbengwi sands exhibit a WAC less than 6%, with CS and FS values between (20.7 – 27.6) MPa and (2.8 – 4 .1) MPa respectively at 35% PET content which can be used for pedestrian walkway applications suggesting feasibility of considering this practice as a solution to plastic waste mismanagement in the town of Bamenda.

Keywords: **Various sands, Gravel 5/15, PET Plastics, PET content**

1 Introduction

The increasing use of plastics has led to significant environmental concerns, particularly in developing countries with inadequate waste management infrastructure. Bamenda, Cameroon has been severely impacted by the Anglophone crisis, resulting in a 25% increase in plastic waste accumulation (Ngong et al., 2021; Tume et al., 2022). This has led to environmental degradation, pollution and harm to aquatic life. A potential solution lies in using plastic waste as a binder in pavement block production, offering benefits such as reduced plastic waste, lower costs, and improve durability (Osinubi et al., 2018; Li et al.,2020). However, the properties of pavement blocks can be influenced by the characteristics of aggregates like sand (Neville, 2011). This study investigates the effects of different sand sources on the properties of plastic pavement blocks, aiming to develop sustainable and cost-effective solutions while addressing the environmental issue in Bamenda.

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2 Materials and Methods

2.1 Materials

For this study, the following materials were used: polyethylene terephthalate (PET), multiple fine aggregates (river sands), and coarse aggregates (gravel 5/15).

Polyethylene terephthalate (PET) sourced from small dump sites within the Bamenda Urban area.

The fine aggregates used in the research were five natural river sands from the main supply sources in the Mezam Division, North West, Cameroon. They comprised sands samples from Chomba, Mbatu, Mbengwi, Ndop and Wum. The properties were determined in accordance to NF and ASTM standards.

The coarse aggregate for the research was 5/15 gravel were. Sieve analysis was done on the coarse aggregates in accordance to, NF EN 933-1

a

b

c

Figure 1: A sample of materials used in the study. a) Collected PET waste; Shredding process of the PET waste; Shredded PET waste; b) Sample sand from one of the sand pits; c) Gravel 5/15.

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2.2 Methods

2.2.1 Experimental flow chat

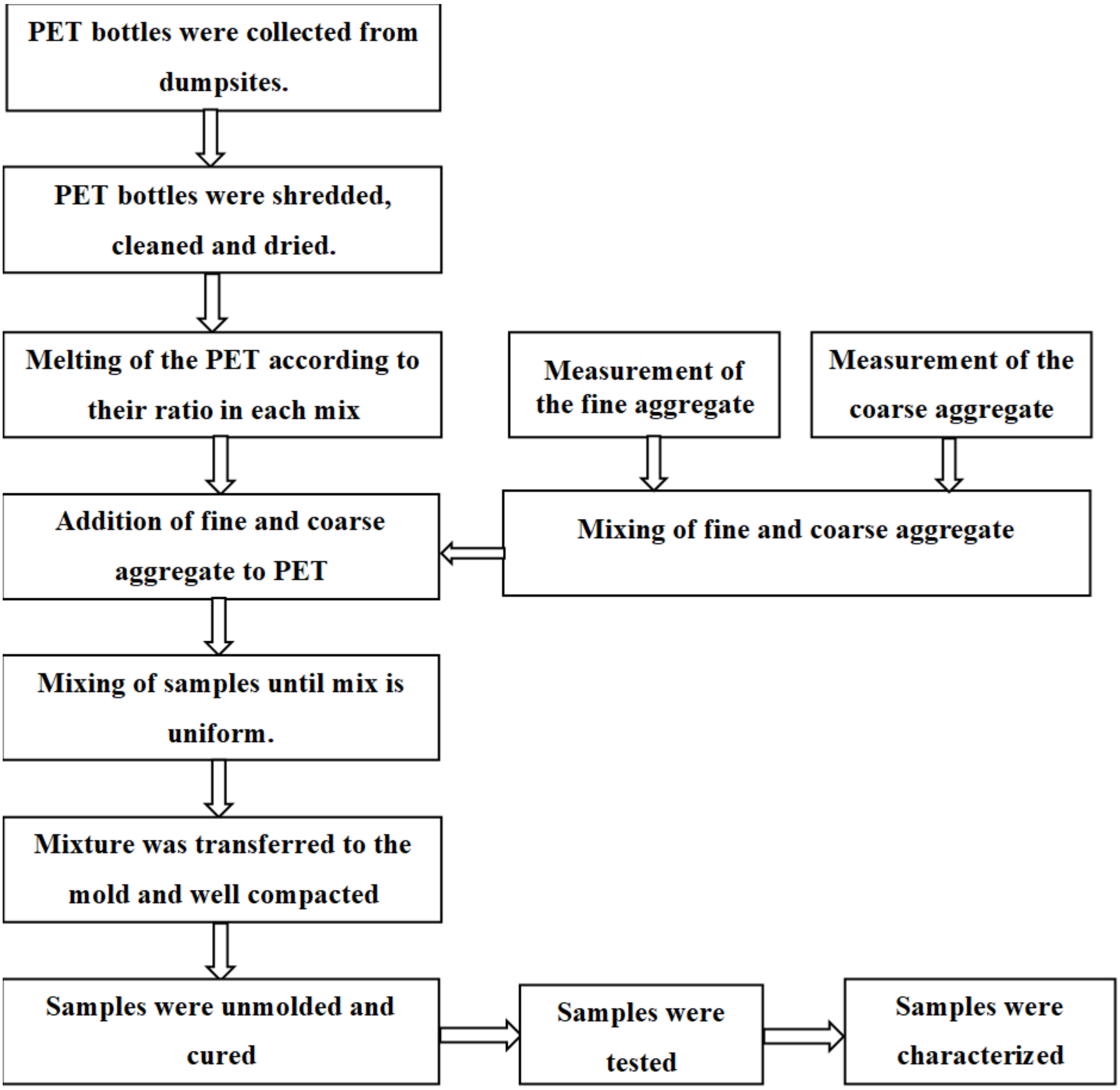

Figure 2: General framework diagram of plastic pavement production for each sand sample.

2.2.2 Samples collection

Sand samples were collected from main suppliers representing the different geological regions. The Samples collected following the French specifications of NF EN 12620 (2002), then separated using the quartering method conforming to ASTM D75-19 (2019).

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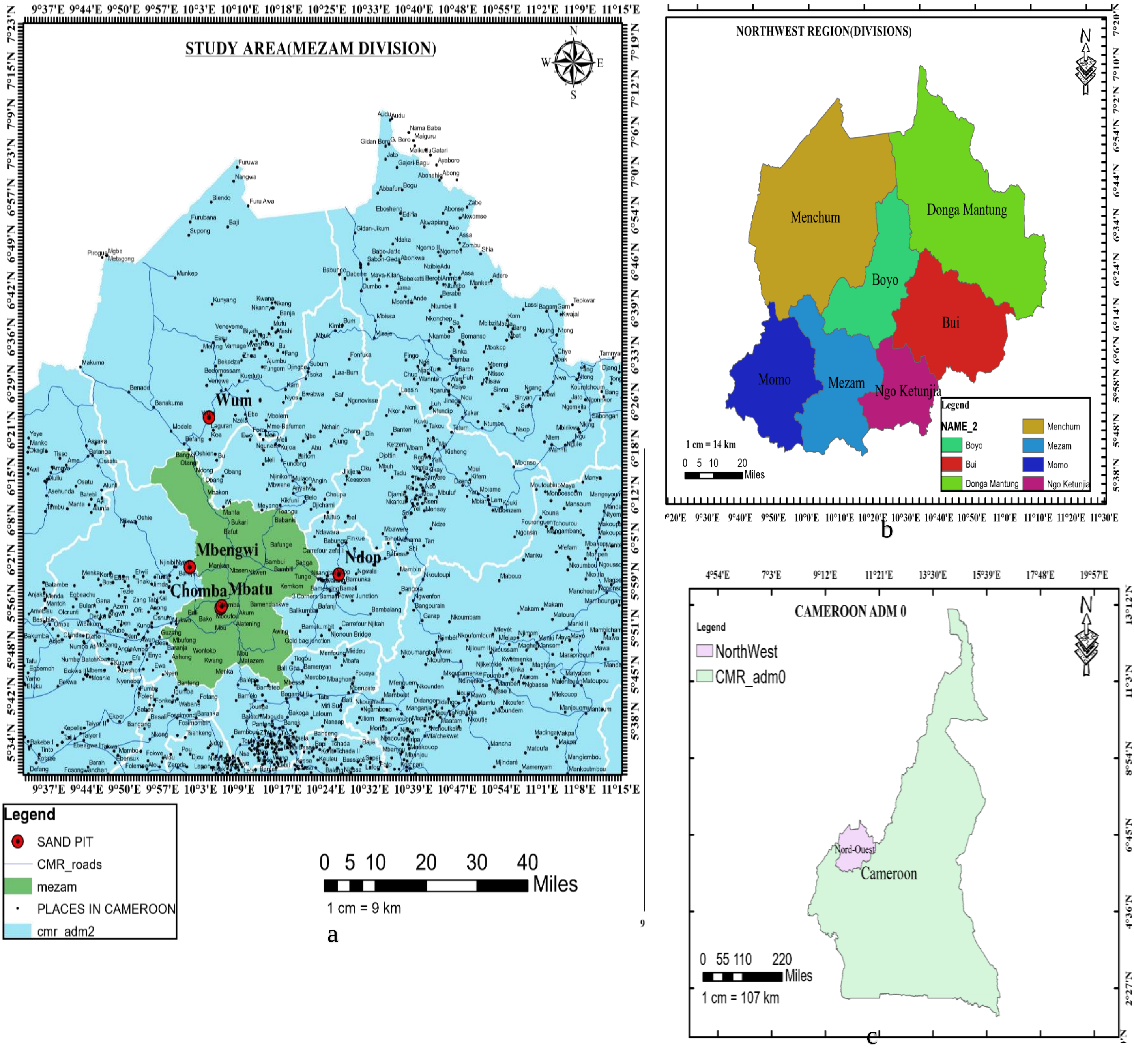

Figure 3: Localization plan of the study area (a, b, and c)

2.2.3 Material preparation

Samples of sands and 5/15 gravel were oven dried at 105 ºC for 24 hours. Then, kept at room temperature to cool before identification tests. Haven removed the lids and paper labels of the PET, they were manually shredded using scissors, washed and dried.

2.3.4 Characterization of raw materials

Physical characterization tests such as; apparent density, specific gravity, particle size distribution sand equivalence and were carried out on each of the sands and the 5/15 gravel. Additional tests such as the Los-Angeles abrasion, cleanliness and flakiness index was also

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carried out on the gravel. Likewise, we carried out specific gravity test on the shredded PET plastic samples.

2.2.4 Design of the experiment

Surface Response Methodology (SRM) is a statistical technique utilized to analyze the relationship between independent variables (factors) and dependent variables (responses) to determine the optimal conditions for achieving desired outcomes Briassoulis D. et al., 2013). Conversely, according to Abu. Duguma et al., (2024) and Alyousef R. et al., (2021), Box-Behnken Design (BBD) is a specific experimental design method that enables researchers to methodically manipulate independent variables within predetermined ranges to identify optimal conditions for maximum response. Response Surface Methodology (RSM) was employed to analyze response surface plots, which visually illustrate the impact of various factors (PET percentage and curing conditions) on the properties of the plastic pavements produced from the various sands in this study. This visualization helped in recognizing model conditions for attaining optimal mechanical properties. By utilizing SRM and BBD, researchers can potentially reduce the number of experiments required, leading to time and cost savings in the industry setting and in further (Abu Duguma et al., 2024).

In this study, our prime objective was to identify the conditions that would lead to the maximum response in terms of mechanical properties, which encompassed compressive strength (CS), flexural strength (FS), and water absorption capacity (WAC), of the produced plastic pavements for each of the sands used in the study and be able to classify in terms of domains of application of the plastic pavements from these sands. The formulation of the materials in their ratios is shown in table 1 with PET at contents ranging from 20% to 50% in 5% increments.

Table 1: The percentage of each sand to gravel 5/15 with respect to the Dreux formulation

Sand Source	Fine aggregate % (sand)	Coarse aggregate % (Gravel 5/15)
Chomba	43.5	56.5
Mbatu	43	57
Mbengwi	41	59
Ndop	44	56
Wum	43.5	56.5

The goal line was to find an optimal aggregate-to-plastic ratio that enhances mechanical properties and durability while ensuring suitable workability and processability for mold filling and compaction during manufacturing. For the various trials, a procedure for preparing samples was adopted. Batched plastic waste was place in an aluminum

i. Melting and mixing

The shredded PET plastics for each mix were melted in an aluminum pot using sawdust and wood as our heat source for constant heating of the plastics until they were completely liquefied. The temperature at the melted state of the plastics noted using a thermometer to

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be averagely 190 0C and melting process took averagely 32 minutes. According to Athanas. Konin. (2011), a melting temperature of 170 0C is recommended for this process, as it ensures complete melting and liquefaction of the PET plastic waste within 20 minutes which was not the case given our environmental constraints and considering that our plastics were only shredded as opposed Eric Ababio O. et al. (2014). Once the plastics were completely melted, the preheated aggregates were added in bits into the melted plastic paste and churned to attain a homogenous mixture.

ii. Molding

Steel molds of dimensions 7x7x7 cm and 16x4x4 cm were used for molding of the composites. These dimensions were selected based on the requirements of the British Moulton Test standard method and the specifications of the RMU serial 1461288 flexural test machine with a three-point bend setup. It was also necessary to heat the molds before molding process. The heated molds permitted gradual loss of heat by the paste permitting proper vibration. The hot paste was placed in the hot, greased, steel molds. During this casting process, a trowel was used to pack the paste into the mold, followed by manual compaction using a 2 kg hammer. After placement, samples were left to gradually loss heat and cool before being unmolded and air dried while 3 placed in water for 24 hours. By using the Box-Behnken Design (BBD) method to explore the effects of the plastic-to-aggregate ratio, we were able to attend the optimal conditions for realizing the best mechanical properties of the plastic bonded pavements. Using the Box-Behnken Design (BBD) to obtain the optimal plastic content enables us gain time in the industrial-scale production levels.
us gain time in the industrial-scale production levels.

a b

Figure 4: Heating of raw materials (a) and moulding of the composite paste (b).

iii. Cooling, drying, and curing of the developed composite.

After the paste was poured, compacted in the mold and removed, and left at room temperature. This step is essential to prevent thermal shock and allow for gradual

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temperature adjustment, ensuring optimal rigidity and strength of samples. Following the initial cooling phase, some of the composite samples underwent 24 hours and 7 days air drying process at room temperature. Once the samples were cooled, the next phase involved testing their mechanical properties. This included assessing flexural strength, water absorption capacity, and compressive strength to see if the pavements meet the required standards for quality and performance according to ASTM C1262 and ISO62:2008.

2.2.5 Plastic pavement characterization

We focused on three key properties: water absorption, flexural strength and compressive strength of the composites. These properties were prioritized as they are crucial for assessing the plastic pavements' ability to withstand loads during construction and use. The comparison of these properties to standard requirements of pavements helps us to evaluate the performance of the pavements developed. Compressive strength, flexural strength and water absorption directly impact the durability and performance of the pavements under usage conditions, and the bonding within the pavement, ultimately defining their resistance to external forces. These tests were carried out as follows:

Water absorption test of sample pavements

The water absorption test measures the amount of water that was absorbed by the pavements. The water absorption test was conducted following the AASHTO T-84 standard test method.

Water aborption= Wf-W_0W0x100% (1)

Where Wf is the weight after immersion in water for 24 hours and W0 is the dry weight before immersion in water. Three samples were used for one and the average taken.

Flexural strength test of pavements

The test involves subjecting the pavement specimens, with dimensions of 16x4x4 cm, to bending forces to evaluate their resistance to shear and impact forces encountered during handling, transportation, construction, and use. The flexural strength test was conducted at the civil engineering laboratory at the Government Technical High School Bamenda, Cameroon using the RMU serial 1461288 flexural test machine with a three-point bend setup in a laboratory setting. The flexural strength under the three-point bending setup, is defined in equation (2) as specified in the testing standard.

σ=2PL/(3bt^2) (2)

Where, b = Span or width of the sample (mm), P = is the failure load (kN), σ = flexural strength (MPa), t = thickness of the pavement (mm), L = total length of the pavement (mm).

Compressive strength test of pavements

The compressive strength test of the pavement is crucial in assessing their ability to withstand compressive forces or loads. This test was used to determine the maximum load that the pavement can tolerate before failure calculated using equation (3) bellow. This test was conducted at Geostruct laboratory in Bamenda, Cameroon.

P=F/A (3)

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Where P is applied pressure (MPa), F = crushing load (N), A = area of samples (pavement) contacted with the load (mm2).

b

c **d**

Figure 5: Submerged samples for testing water absorption testing and other properties (a), Flexural strength test for 16x4x4 cm samples (b) and Compressive strength test for 7x7x7 cm samples (c).

2.2.6 Classification of developed pavements.

Comparing the developed plastic pavements using the different sands at varying plastic percentages, with standard pavements according to ASTM C1262 standard code for their flexural strength, compressive strength and according to ISO62:2008 for water absorption capacity was crucial in evaluating the composite's performance and suitability for different applications. The classification of the pavements for their area of application was also crucial for recommending to the general public on the sand source and the optimal plastic content which produces the highest overall properties which eventually is best for plastic pavement construction practices around the city of Bamenda. Table 2 and table 3 gives the compressive and flexural strengths of pavements and their areas of applications as recommended by the ASTM C1262 standard code. These standard values were used to compare the properties of the developed plastic pavements.

Table 2: Compressive strength and area of application according to ASTM C1262

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Compressive strength (MPa)	Area of applications
27.6 - 41.4	Packing lots, driveways
20.7 - 27.6	Pedestrian walkways
17.2 – 20.7	outdoor patios

Table 3: Flexural strength and area of application according to ASTM C1262

Flexural strength (MPa)	Area of applications
2.8 - 4.1	Packing lots, driveways
2.1 - 2.8	Pedestrian walkways, outdoor patios

In terms of water absorption, ISO62:2008 recommends that the water absorption capacity of pavements used for any application should not exceed 6%. This standard was the baseline for evaluating the composites in terms of water absorption capacity using the different sands from the sand pits we studied.

3 Results and Discussions

3.1 Results

The specific gravity of the sands, PET plastics and gravel.

The results for the raw materials used in this study are presented in Table 4, indicating how their densities compare to that of distilled water. This information was valuable for understanding the characteristics of the materials being studied in this research.

Table 4: Specific gravity results of sands, gravel and PET plastics

Test method	Raw Material	Specific gravity	Standard
ASTM C128 (2021)	Mbatu sand	2.433	2.0 - 2.66 for pure fine sand (British standards).
	Ndop sand	2.427	
	Chomba sand	2.537	
	Mbengwi	2.501	
	Wum sand	2.454	
ASTM C127 (2021)	5/15 gravel	2.605	2.60 - 2.75 for most gravel (ASTM standard)
ASTM D2395-17	PET plastic	1.395	1.38 -1.40 from literature (Bartholmew, R. F., & Kongieczny, S. D. (2003).

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The sand equivalence of the various sands

Table 5: Results of the sand equivalent values of the various sands

Test method	Raw Material	Sand equivalence (%)	Standard
ASTM D2419	Mbatu sand	65.20	ASTM standard
	Ndop sand	66.46	
	Chomba sand	80.52	
	Mbengwi	86.64	
	Wum sand	75.29	

Grain Size Analysis

The results of the sieve analysis of the various sands and 5/15gravel is presented in figure 8 below.

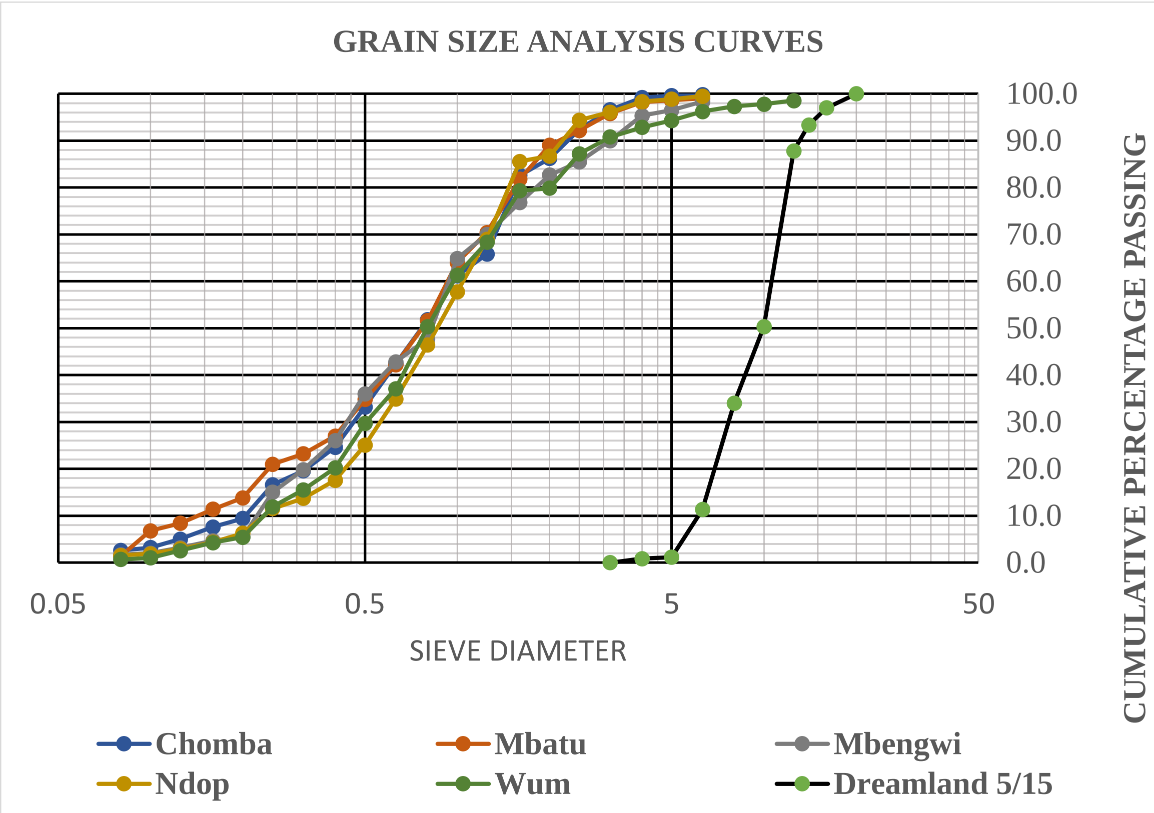

Figure 6: Sieve analysis results of the aggregates

The additional tests on the 5/15 gravel

These additional tests include; the Los-Angeles abrasion, cleanliness and flakiness index of the gravels.

Based on the test of the dirt content of the 5/15 gravel used in this study from the Dreamland quarry depicts that 1.18 % of the sample is made up of dirt.

The resistance to abrasion of the gravel for a rotation speed of 0.55Hz was noted to be 23.21% and the flakiness index of the aggregate being 23.0%

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Physico-mechanical characteristics of the pavements developed.

The results of the samples made from each sand follow a similar trend which shows that the water absorption capacity of the composite material decreases gradually with the addition of PET at formulations ranging from 20% PET to 50% PET of 12.73% to 3.88% for Mbatu sand, 12.22% to 2.13% for Ndop sand, 6.87% to 1.65% for Chomba sand, 4.83% to 1.37% for Mbengwi sand and 10.17% to 1.68 for Wum sand respectively as a function of PET content is presented below.

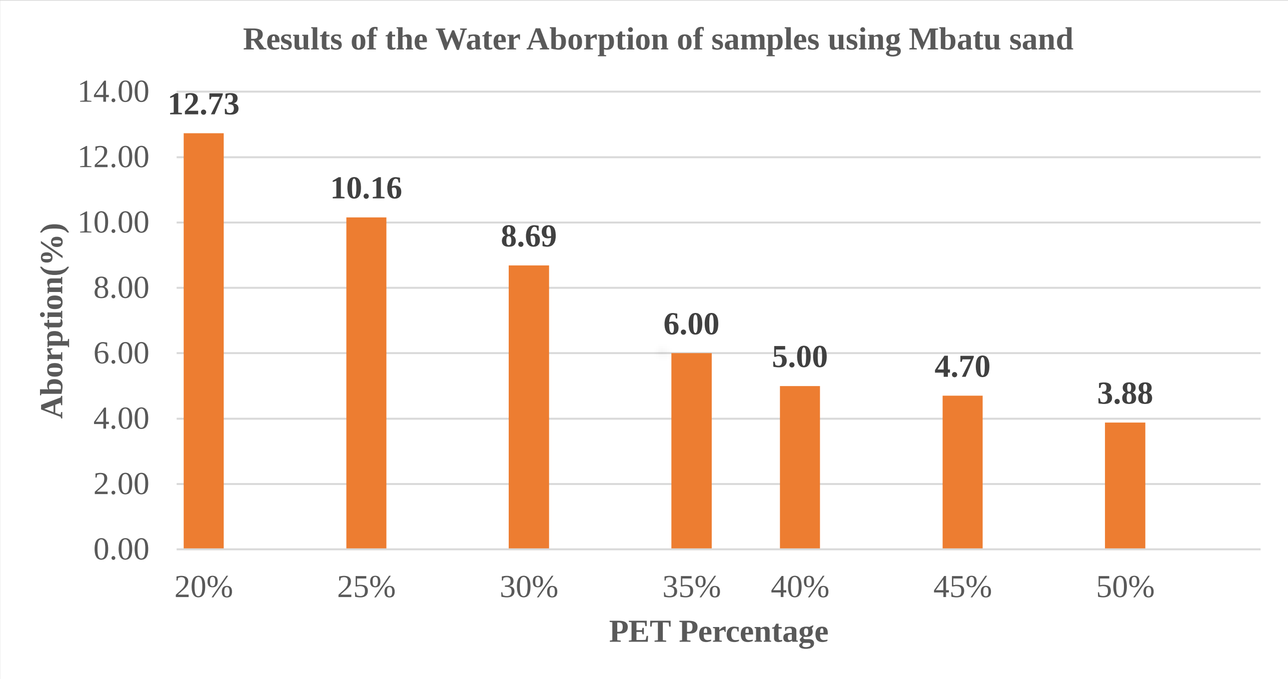

Figure 7: Histogram of water absorption of material samples using Mbatu sand

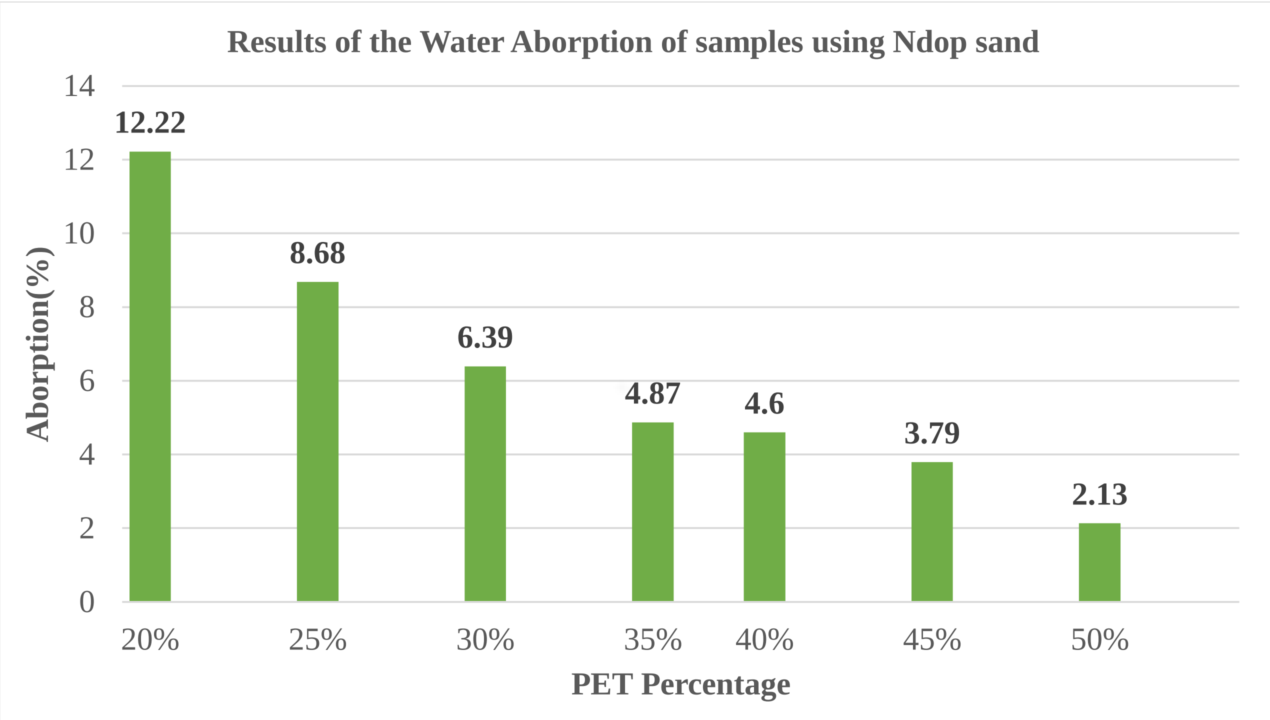

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Figure 8: Histogram of water absorption of material samples using Ndop sand

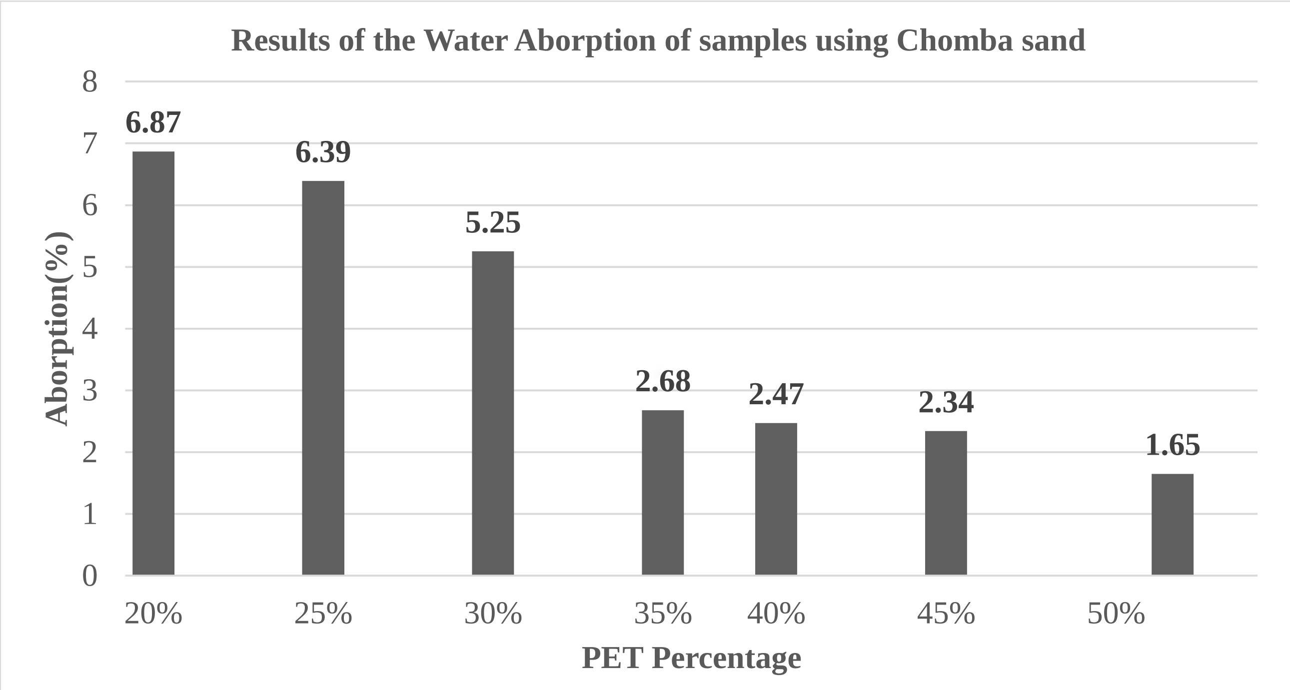

Figure 9: Histogram of water absorption of material samples using Chomba sand

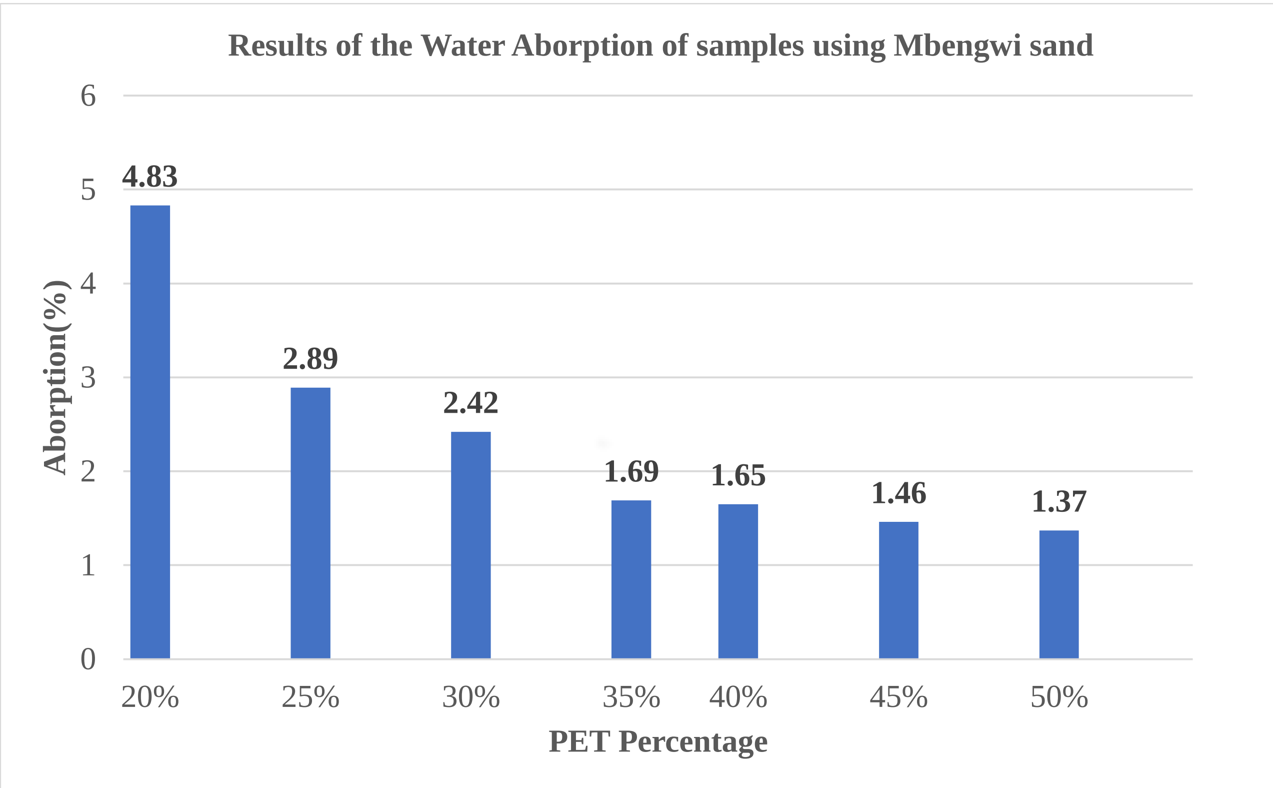

Figure 10: Histogram of water absorption of material samples using Mbengwi sand

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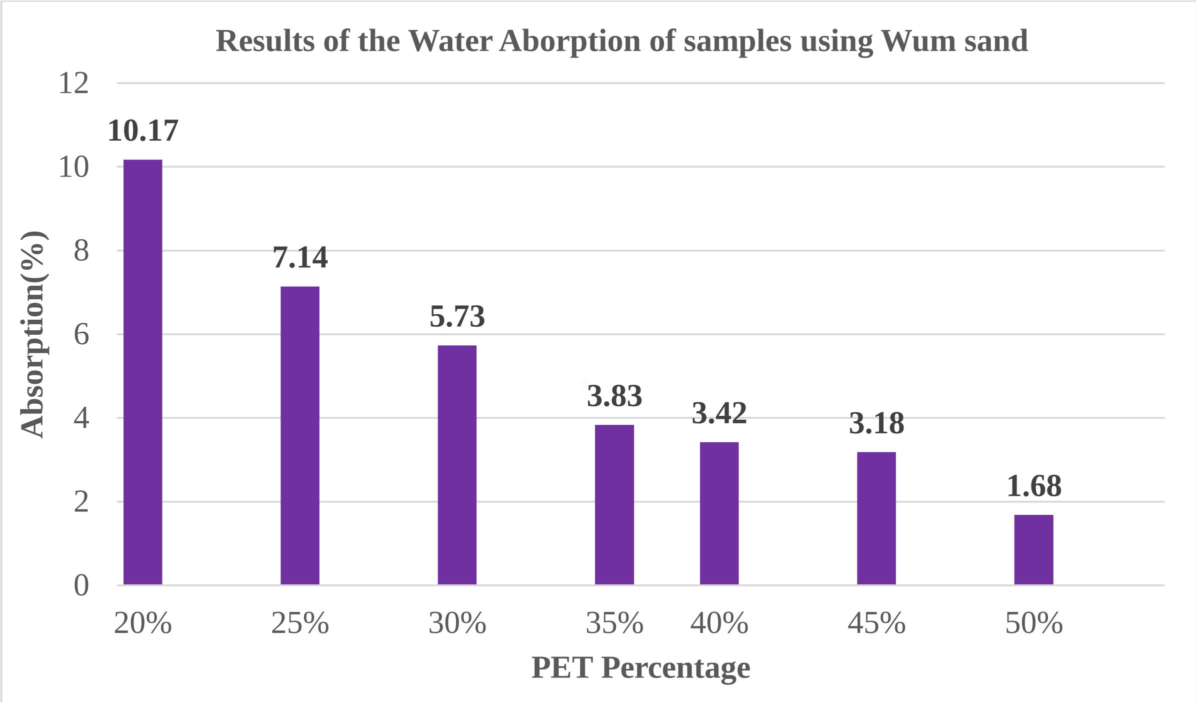

Figure 11: Histogram of water absorption of material samples using Wum sand

Compressive strength of the composites as a function of PET content

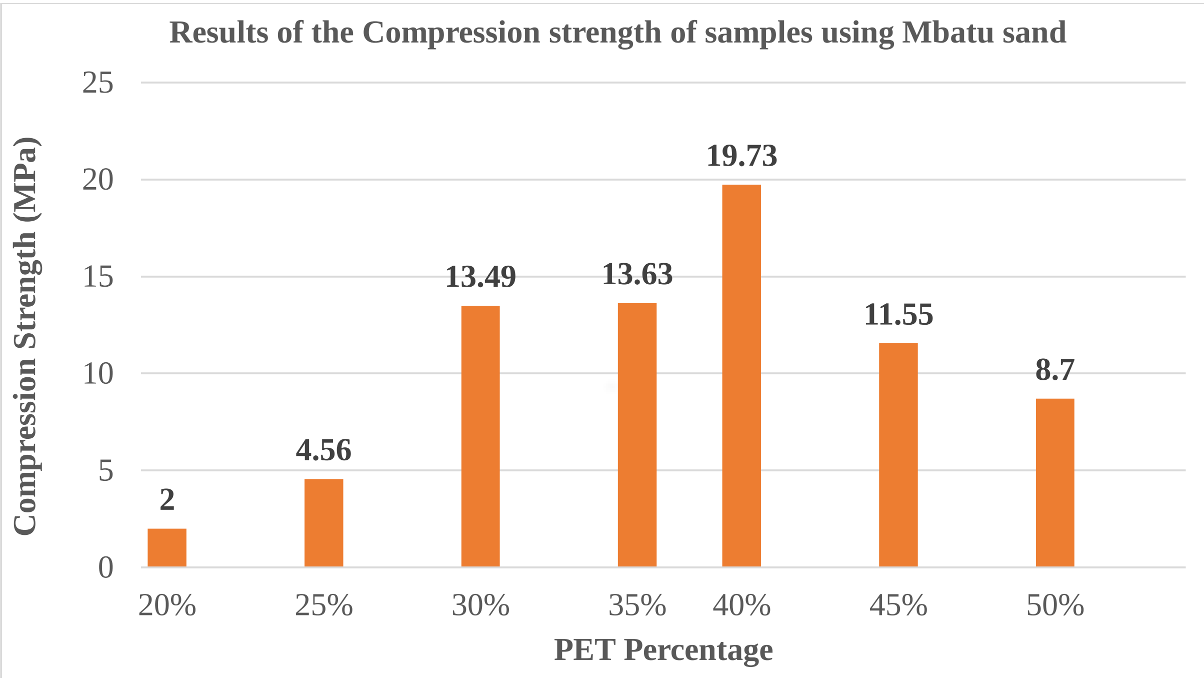

Figure 12: Histogram of Compression strength of material samples using Mbatu sand

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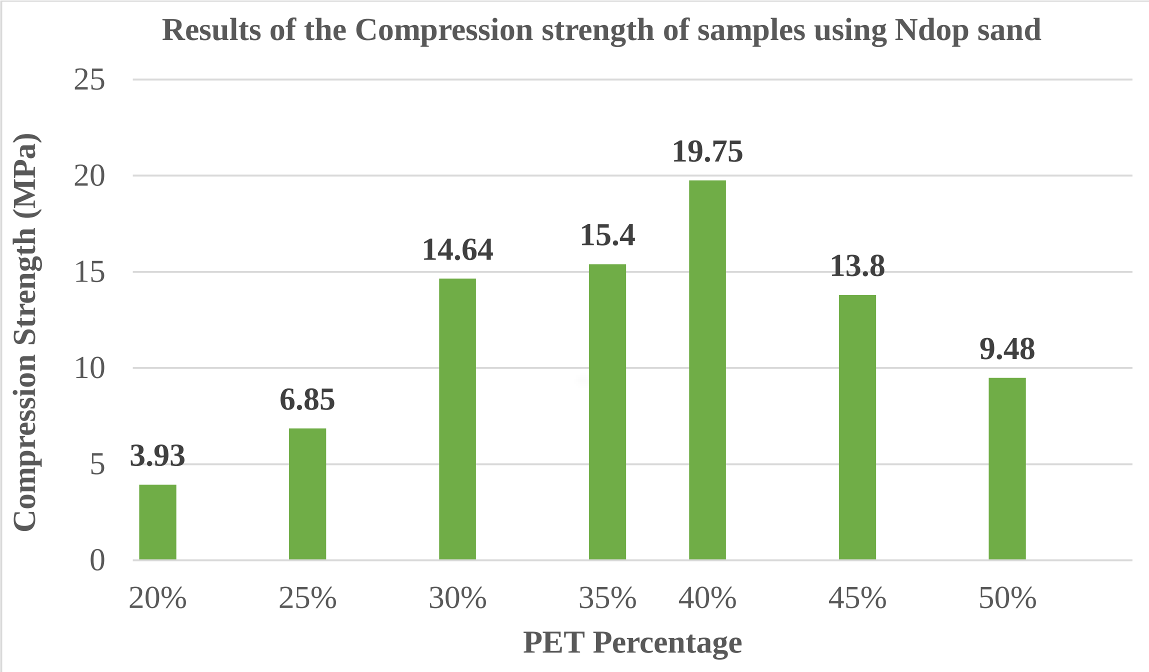

Figure 13: Histogram of Compression strength of material samples using Ndop

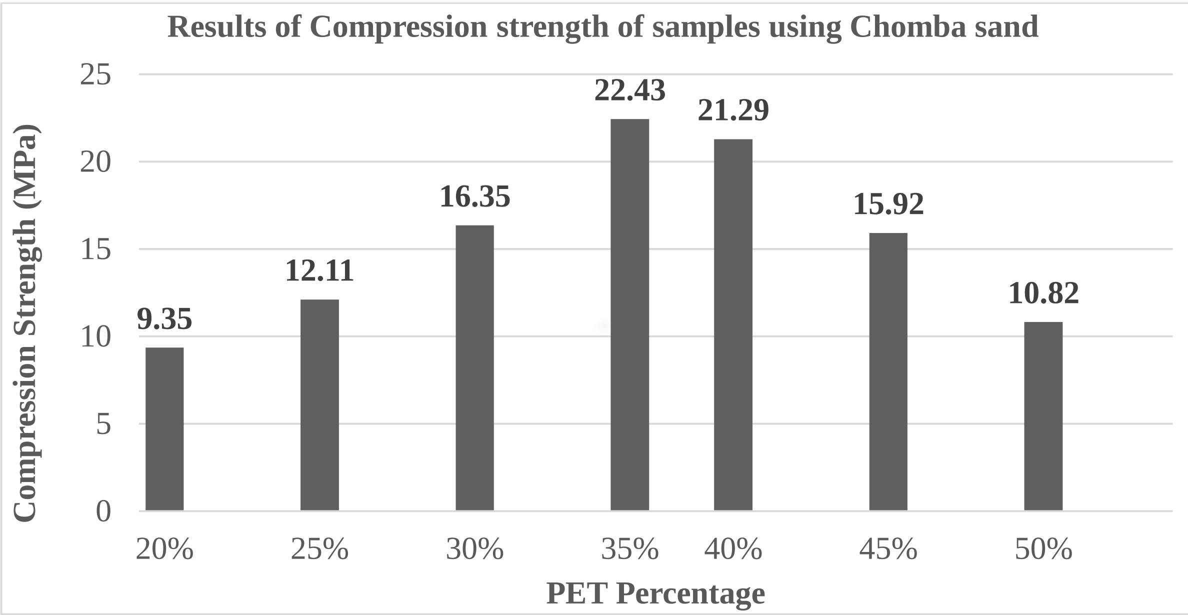

Figure 14: Histogram of Compression strength of material samples using Chomba sand

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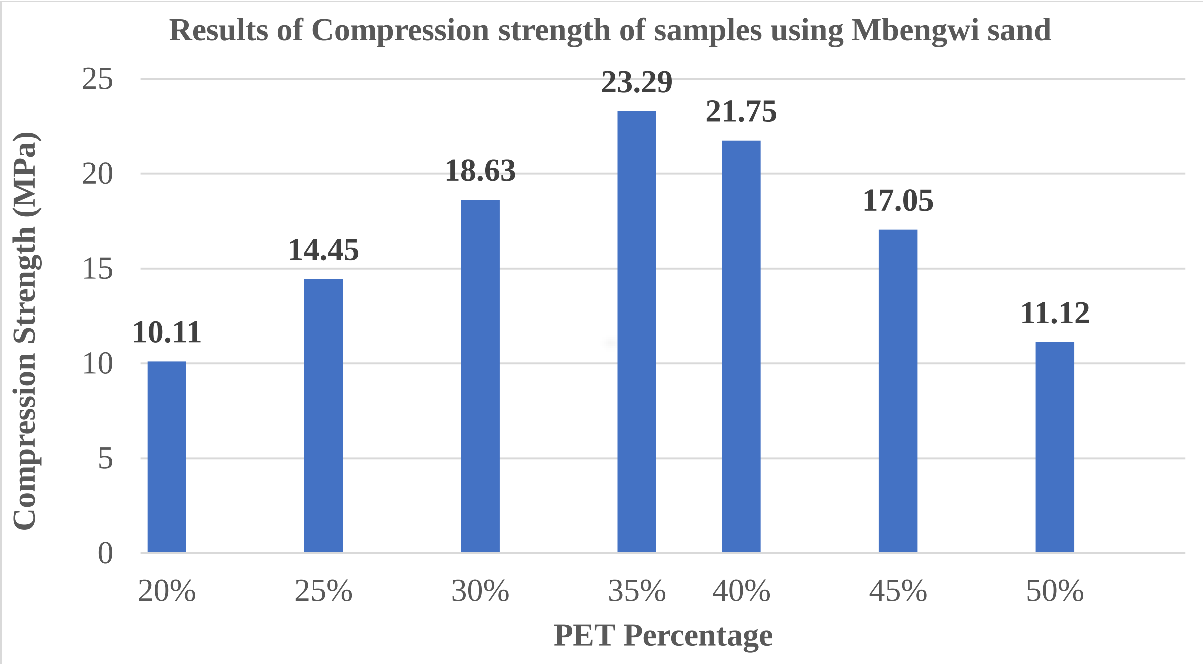

Figure 15: Histogram of Compression strength of material samples using Mbengwi sand

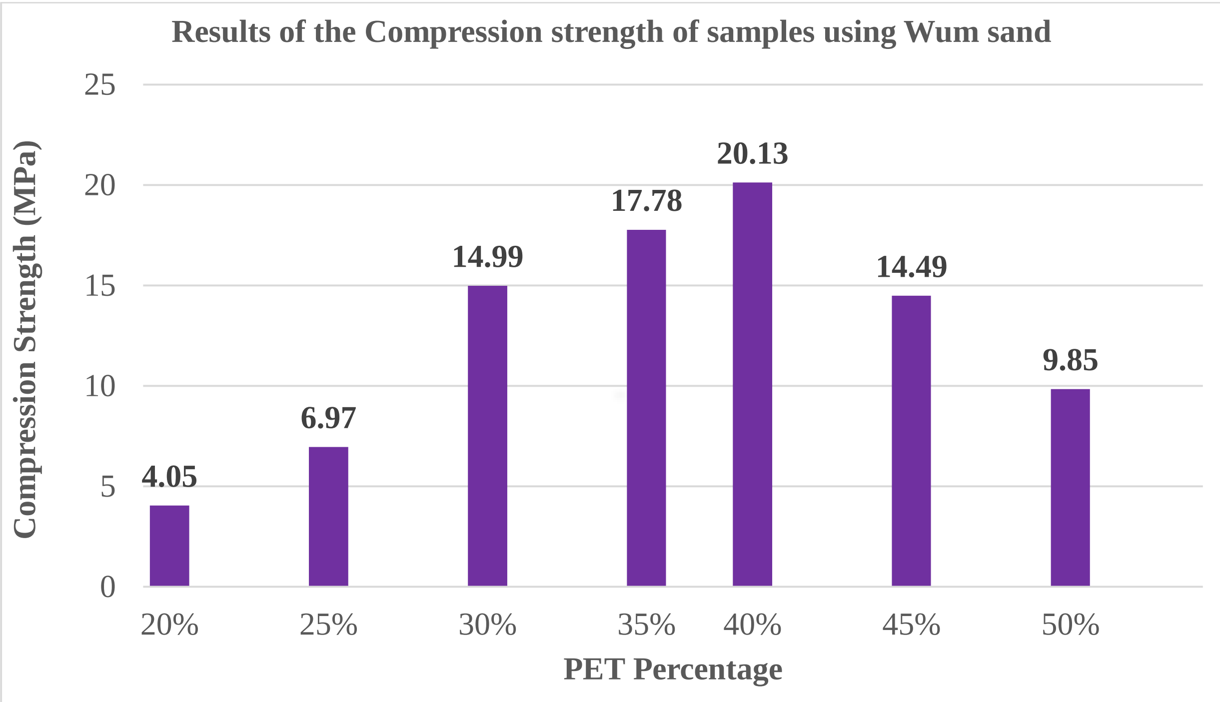

Figure 16: Histogram of Compression strength of material samples using Wum sand

Looking from the results of water absorption capacity of the composites produced from the sands in this study, we observed that as the PET the content increases, water absorption decreases substantially and progressively due to decrease in pores. Thus, from our observation, PET content influences our composite and most importantly less than 35% PET content is not advisable for use with sands from

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Mbatu and Ndop, less than 30% PET content is not advisable for use with sands from Chomba and Wum regardless of other properties. This is in line with the ISO62:2008 standard, which assumes a maximum water absorption of 6% for concrete pavements. From our study, we observed that even at 20% PET content, the Mbengwi sand composite still shows a water absorption capacity less than 6% unlike other composites. This may be explained by the high sand equivalent value (86.64%) of the sand compared to the other sands in this study. Sands with higher sand equivalence absorb less water compared to sands with lower sand equivalence. This is because the sands with higher sand equivalence have fewer clay or silt content and these sands interlock better preventing water absorption in the composite hence consequently leading to a decrease in the water absorption capacity of the composite which this view is in line with that of Ahmedzade & Sengoz. (2009). The general observation made was the fact that the water absorption capacity reduces with increase in PET content. This may be due to the fact that the PET plastics function like a water repellent (hydrophobic property of PET) by completely covering most voids for possible water absorption especially the surface of the composite. This view is in line with the observation made by Ludovic Ivan *et al*. (2023) on plastic made tiles.

Flexural strengths of the plastic pavements as a function of PET contents.

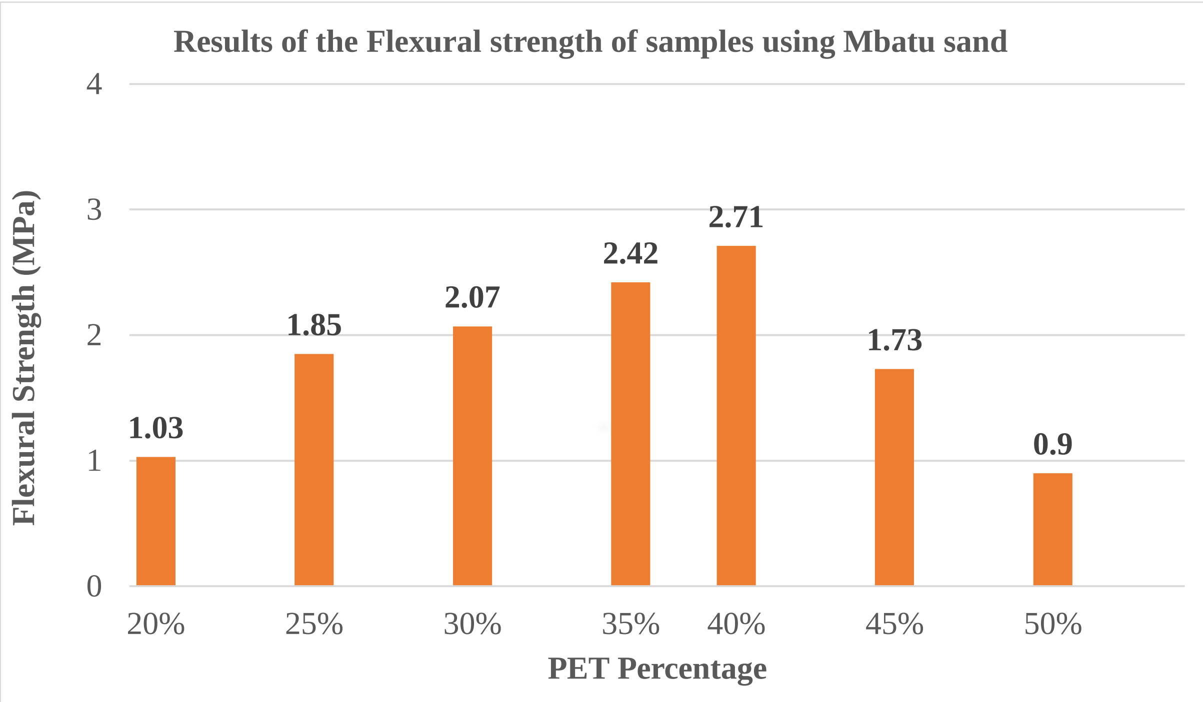

Figure 17: Histogram of Flexural strength of material samples using Mbatu sand

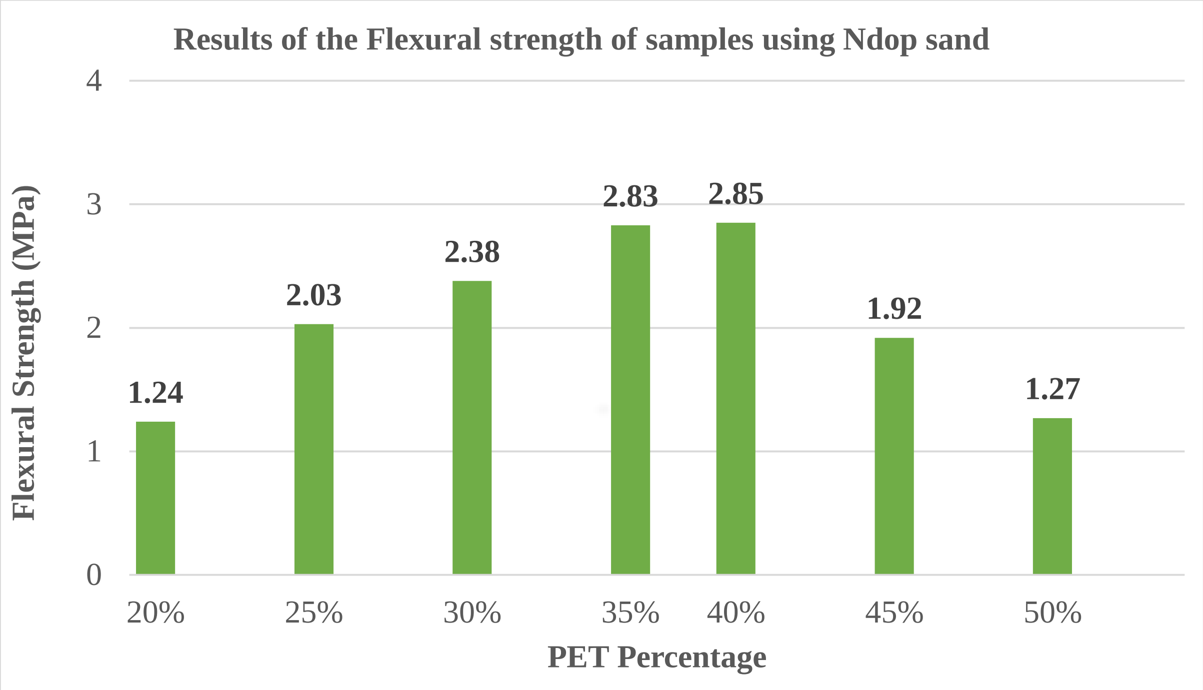

Figure 18: Histogram of Flexural strength of material samples using Ndop sand

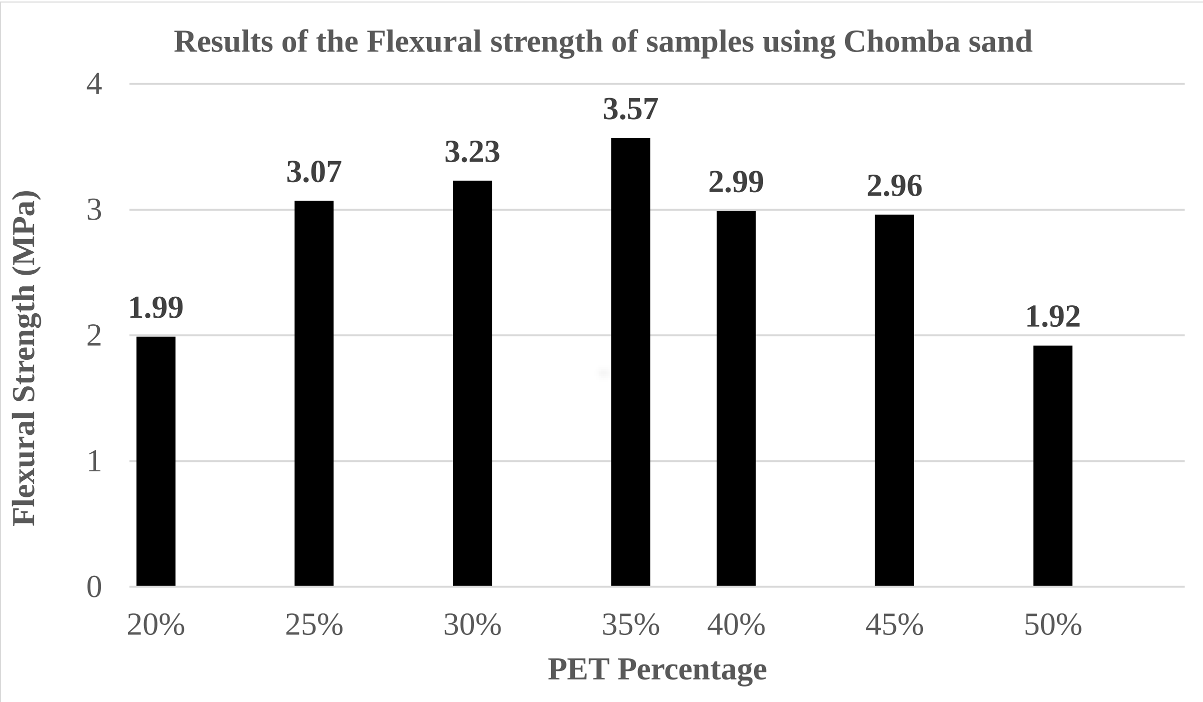

Figure 19: Histogram of Flexural strength of material samples using Chomba sand as a function of PET content

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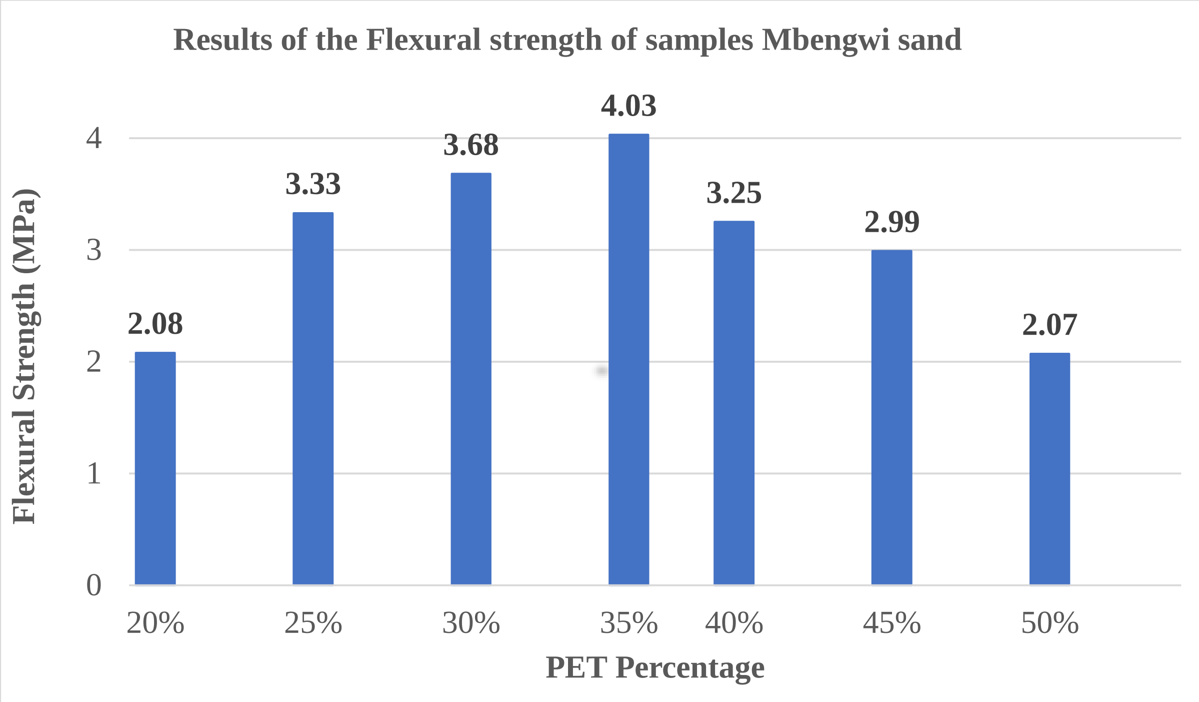

Figure 20: Histogram of Flexural strength of material samples using Mbengwi sand as a function of PET content.

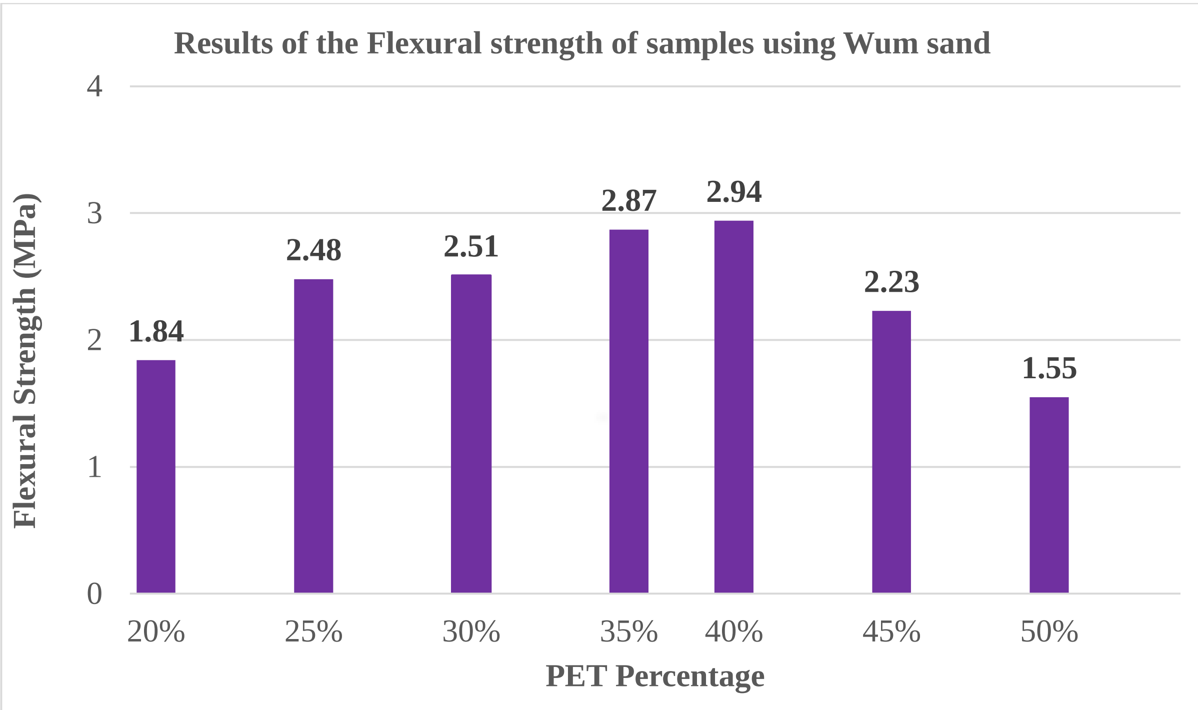

Figure 21: Histogram of Flexural strength of material samples using Wum sand

Generally, the compressive and the flexural strength of the composites were observed to increase with the addition of PET to a maximum value before a drop increase in compressive and flexural strength up to certain values before a fall. From the tables of compressive strength, we see the composites show

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maximum compressive strengths of 19.73 MPa, 19.75 MPa, 22.43 MPa, 23.29 MPa and 20.13 at 40%, 40%, 35%, 35% and 40% PET content respectively for composites samples developed using Mbatu, Ndop Chomba, Mbengwi and Wum sands respectively. Also, the results of the flexural test show that a maximum of 2.71 MPa, 2.85 MPa, 3.57 MPa, 4.03 MPa and 2.94 MPa at 40%, 40%, 35%, 35% and 40% PET content respectively for composites samples developed using Mbatu, Ndop Chomba, Mbengwi and Wum sands respectively.

The above observed trends in compressive and flexural strength, which peaks at a certain point before declining, along with the progressive decrease in water absorption as plastic waste content increases suggest that an optimal amount of plastic waste is necessary to achieve the best aggregate-plastic packing and composite performance. This finding is supported by Moundom et al (2023). The binding strength between plastic and grains in the composite appears to depend on the thickness of the plastic binder film, as also observed in studies on bitumen (Hyzl et al., 2016) and recently by Nfor et al.(2024). Deviating from the optimal plastic waste content result in a plastic binder film that is either too thin or too thick, compromising bond strength. This contradicts the view of Ludovic et al. (2023). As plastic content increases beyond the optimum, the composite packing becomes increasingly disrupted due to the growing distance between grains caused by the thicker plastic binder film (Osinubi et., 2018). Nevertheless, the existence of an optimal plastic binder content aligns with the study of Ludovic et al. (2023).

3.3. Optimal physico-mechanical characteristics of pavements developed

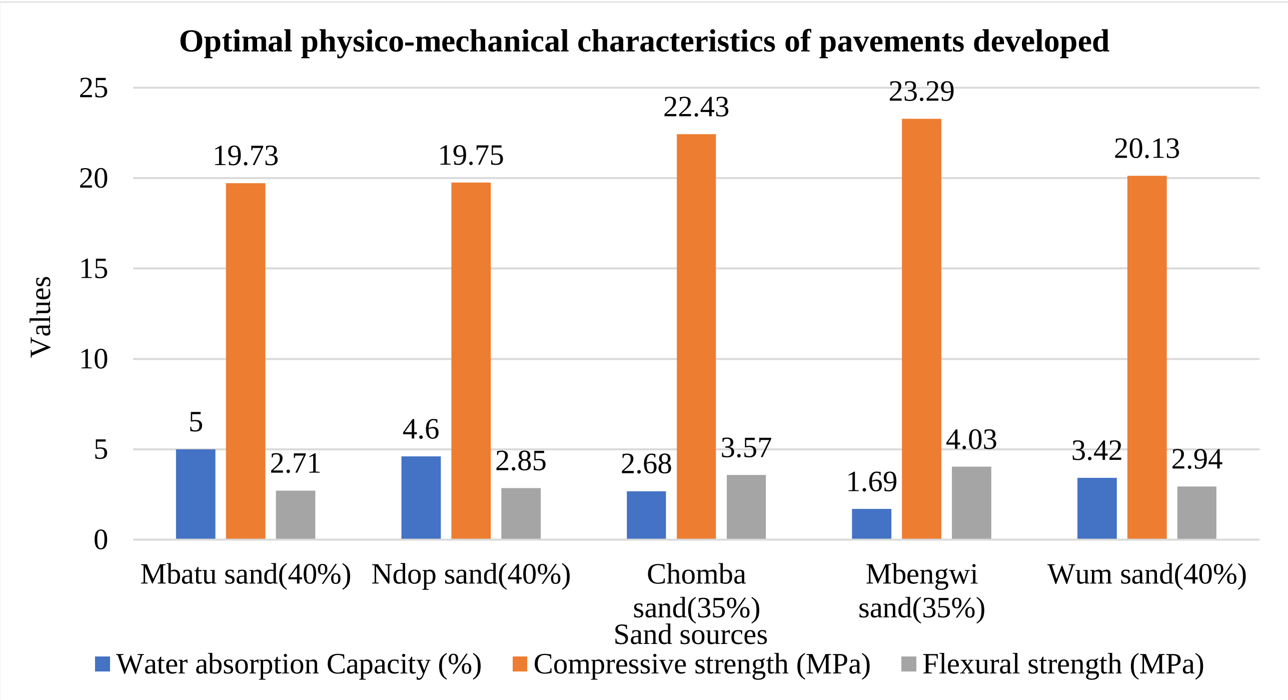

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Figure 22: Optimal physico-mechanical characteristics of pavements developed

From the results of the water absorption, compressive strength and the flexural strength, we see that optimal conditions for the composites from the various sands were attended at different PET content. We extracted the optimal conditions for each of the composites to be able to see the domains (packing lots and driveways, Pedestrian walkways and outdoor patios and decks) of application for each of the composites as recommended by the ISO62:2008 and ASTM C1262 standard code.

3.2.3 Grouping of the composites according to their domain of applications

Results from this study according to ISO62:2008 and ASTM C1262, at 40% PET plastic content the composites produced from Mbatu, Ndop, and Wum can be used for outdoor space. The composites produced from the sands from Chomba and Mbengwi at 35% PET content can be used Pedestrian walkways.

3.2.5 The lapses of non-industrial production

The methods used in this research were basically artisanal production procedures involving mainly hand tools and therefore we recognize that with our manual methods such as manual compaction using the hammer may have lowered the expected results. Compaction plays a vital role in determining the geotechnical properties of the composite irrespective of aggregate size and binder according to Mehta and Monteiro, (2014) and ACI, (2019), which suggests that proper compaction reduces porosity. There was no way we accounted for proper and uniform compaction throughout the experimental period. Studies such as that of Eric Ababio O. et al. (2014) and Abu. Duguma et al. (2024) made used of ground plastics which enhanced the melting process and reduced melting time of the plastics. We simply just shredded our PET plastics in this study which may have increased the melting time to be more than the time of complete melting suggested by Athanas. Konin. (2011) in his study. These challenges can be tackled at industrial level with better environmental conditions and better tools. It therefore stands that if shredding, heating, mixing and compacting methods can be enhanced, quality pavement blocks for pedestrian walkways and outdoor patios can be produce by artisanal means, a production process that can be easily setup with limited capital.

4 Conclusions, Discussion and Perspectives

4.1 Conclusions

The Anglophone crisis in Cameroon has disrupted waste management services in the town of Bamenda and so there has been reported increase of 25% in waste on the streets since the start of the crisis with 60% of the waste being plastics. These plastics do not only cause the town to be unpleasant but the plastic waste as well pollutes the water bodies, harming aquatic life and disrupting ecosystems. Environmentally friendly and sustainable construction practices offer a potential solution to adding value to these plastics and as well addressing an environmental problem. One approach is the use of plastic waste as a binder instead of cement which we know it is not environmentally friendly and expensive for pavement blocks production, offering several advantages which could be: Reducing plastic accumulation in our environment Lower costs and improved durability and strength. Regarding situation in Mezam Division in the Northwest Region of Cameroon with sands readily available from various sand sources within the Region. This study seeks to explore available sands in the Region on its influence on the properties of plastic bonded pavement while aiming at solving the environmental problem in the city of Bamenda. In the attempt, Mbatu, Ndop, Chomba, Mbengwi and Wum sands were combined with gravel 5/15 at 20%, 25%, 30%, 35%, 40%, 45% and 50% PET content, tested to spot which sand(s) and can be termed best for such practices. To begin, material samples were first characterized and the composites developed from these materials. The characterization of the composites was done based on; WAC, CS and FS of the composites and classified according their domains of application. The Surface Response Methodology (SRM) and Box-Behnken Design (BBD) methods were used to develop material samples. After the laboratory testing of the composites from these sands. The discoveries of the study show that composites developed from Mbatu, Ndop and Wum sands display a WAC less than 6%, with CS and FS values between (17.2 – 20.7) MPa and (2.1 – 2.8) MPa respectively at 40% PET content which the composites can be used for outdoor space applications. The composites developed from Chomba, and Mbengwi sands exhibit a WAC less than 6%, with CS and FS values between (20.7 – 27.6) MPa and (2.8 – 4 .1) MPa respectively at 35% PET content which the composite can be used for pedestrian walkway applications.

The economic and the environmental impact and overall viability of this innovative study is a solution to plastic waste mismanagement in the city of Bamenda with the use of the natural aggregates.

4.2 Discussions

From our study, we observed that even at 20% PET content, the Mbengwi sand composite still shows a water absorption capacity less than 6% unlike the other sands. This may be explained by the high sand equivalent value (86.64%) of the sand compared to the other sands in this study. Sands with higher the sand equivalence (lower clay and silt content) generally absorb less water than compared to sands with lower sand equivalence (higher clay and silt content). This is because the sands with higher sand equivalence interlock better preventing water absorption in the composite hence consequently leading to a decrease in the water absorption capacity of the composite which this view is in line with that of Ahmedzade & Sengoz. (2007). The general observation made was the fact that the water absorption capacity reduces with increase in PET content. This may be due to the fact that the PET plastics function like a water repellent (hydrophobic property of PET) by completely covering all voids for possible water absorption especially the surface of the composite. This view is in line with the observation made by Ludovic Ivan et al. (2023) on plastic made tiles.

Based on the increase observed in compressive strength and flexural strength to a maximum and subsequently decreases from that maximum and as well following the progressive decrease in water absorption with increasing plastic waste content shows that just an adequate amount of plastic waste needed to achieve optimal aggregate packing for best performance of the composite to be attained. This view is also supported by the study made by Moundom et al., (2023). As observed with bitumen (Hýzl et al., 2016), the strength of the bound plastic-binder on grains in the composite depends on the thickness of the plastic-binder film which is similar the observations of Nfor et al., (2024). This is possibly because below and above the optimum plastic waste content, the plastic-binder film gets too thin or too thick, reducing the bond strength contrary to Ludovic et al., (2023). As the plastic content increases to a maximum, the packing of the composite becomes more and more disturbed since the distance between grains increases with increasing thickness of the plastic-binder film (Osinubi et al., 2018). This observation of having optimal plastic binder content is in line with the study done by Ludovic et al., (2023).

No evident difference in compressive strength was noticed between the sample of the composite block air-cured for 24 hours and the other blocks cured after 7 days indicating that little or no structural change takes place beyond 24-hour of cooling.

4.3 Recommendations

This present study suggests several recommendations for future research to enhance the successful utilization of various sands commonly sold in Mezam Division which can combined with plastics and coarse aggregates for plastic waste pavement production. These recommendations include washing of these sands, optimal mixing of two or more of the various sands. Addressing these recommendations in future research can lead to a more comprehensive understanding of the properties and performance of plastic pavements made from these various sands and PET plastic waste, contributing to environmentally friendly and sustainable construction practice as a potential solution to addressing both the plastic waste mismanagement and development of new materials in the field of material science for infrastructural development.

5 Declarations

The authors declare that they have no known competition in financial or personal interests that could have appeared to influence the work reported in this paper.

Availability of data and materials

The data that support the findings of this study are available with the corresponding author, [Mbuh Moses Kuma], upon judicious request.

Competing interests

No potential conflict of interest was reported by the author(s).

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Authors' contributions

MMK, ND and NMK were the investigators and drafted the manuscript. PJB designed the study,

all authors read and approved the final manuscript.

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