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EFFECTS OF OIL PALM MESOCARP FIBRES ON THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF CEMENT STABILIZED COMPRESSED EARTH BRICKS

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ABSTRACT

This work aimed to investigate the effect of oil palm mesocarp fibres (OPMF) on physical and mechanical properties of cement-stabilized compressed earth bricks. Fibres were pretreated with warm water at 100°C diluted with 1%, 2%, 3%, and 4% (S1, S2, S3 and S4) Sodium hydroxide (NaOH) to eliminate residual oil and then oven dried at 105°C for 24 hours. Soil was stabilized with 10% cement by mass reinforced with fibres. Six different samples formulation of ten each were made with fibres content of 0%, 0.5%, 1%, 1.5%, 2%, and 2.5% using a mold of size $(70\times70\times70)mm^3$ and $(160\times40\times40)mm^3$ for compressive and flexural strengths respectively, then cured for 7,14 and 28days. The compressive and flexural strengths were highest at 28days of curing for composites with 2% fibres composition and S2 pretreatment with 2.4MPa and 2.3MPa

respectively. For S1 to S4 pretreated fibres, composites showed highest densities at 7days for 0% fibres composite. Soil was observed to have a moisture content, liquid limit, plastic limit, organic content, and specific gravity of 27.1%, 51.8%, 26.7%, 12.26% and 2.44% respectively. Fibres were observed to have a lignin, cellulose, hemicellulose, and hollocellulose contents of 15.8%, 46%, 14.73%, 60.73% respectively. Water absorption composites rates for 2.5% fibres were observed to decrease from 13.2% and 11.5% for S1 to S4 respectively after 8hours of samples saturation. Hence S2 and 2% fibres inclusion had the highest mechanical and good physical properties for building.

KEYWORDS: Compressive strength, Flexural strength, Mesocarp fibres, Physical properties, Earth.

1. INTRODUCTION

The use of mud blocks for construction has been an age-long practice. Earthen buildings have existed as one of the methods used by humans to cater for shelter. According to,[1] the use of earth as a building material dates as far back as 2500 BC. Earth bricks reinforced with fibres are applied in the domain of infrastructure, renovation works and building of houses.[2] Over the years, housing has always been one of the basic human needs. Currently, cement structures are highly solicited both in our country and all over the world. However, cement structures suffer from stress-induced cracks attributed to overloading.[3] The provision of adequate housing for both man and livestock has become a challenge around the world, especially in developing countries. This is because of the ever-increasing population. Adequate housing is constrained by the high-cost of building materials.[4] The progressive deterioration of buildings necessitates the development of alternative building materials from locally available raw materials for low-cost housing. These raw materials must be abundantly available and renewable in nature. Earthen construction is known to undergo rapid deterioration under severe weather conditions.[5] In order to reduce cost of manufacturing, one of the solution applied was by using waste as part of bricks production materials.[6-8] Fibre reinforcement of earthen structures improves the ductility, toughness, tensile strength and durability of the stabilized soil in addition to increasing its strength.[2] Various stabilization techniques have been used in order to improve on the mechanical properties of cement stabilized earth-based brick (CSEB).[9] Despite that, this improved CSEB are still vulnerable to harsh climatic conditions of temperature[10] and indoor noise pollution[11]

leading to high energy consumption through the use of fans and air condition systems indoor to mitigate this effect.

In oil palm fibres, the cellulose and the hemicellulose are bonded in a lignin matrix like most natural fibres. They can therefore be referred to as lignocellulose fibres.[12] Poor waste management from oil milling plan lead to air and water pollution when burnt or disposed in to the sea leading to global warming and respiratory infections.[13] The study in this paper seeks to look at ways to give value to this waste so as to offer cultivators of palm an added economic advantage. Hence there is the need to free the environment by recycling these waste normally, the domain of building construction has promoted the valorization of biomass fibers and recycling in a quest to solve problems linked to the environment.[14] In the growing concern of awareness regarding climate change and sustainable development, Compressed Stabilized Earth Block (CSEBs) are energy-efficient and environment-friendly.[15]

Alkaline Pretreatment of oil palm fibres using warm water and NaOH was optimal to remove hemicellulose, lignin and improve the bonding effect of fibres.[16-19] The use of natural vegetable fibres in cement composites gives 10 % reduction in weight, 80 % reduction in energy required for production, and 5 % reduction in cost of component used when compared to a fibres-glass reinforced component.[20]

2. MATERIALS AND METHOD

2.1.Pretreatment and Determine the properties of oil Palm mesocarp fibre

Oil Palm mesocarp fibre**s** were obtained from a legal Cameroonian company processing rubber and oil palm, plantation factory (SOCAPALM) located in SUZA, within littoral Region in Cameroon. The fibres were washed in warm distilled water at 100 °C diluted with 1%, 2%, 3% and 4% NaOH[18] concentration for 30 minutes and furnace dried at a temperature of 105°C for 24hours. Using a vernier caliper, the average length of fibres was determined to be 30 mm. Fig1. a, b, c and d shows the alkaline pretreatment and oven drying of the mesocarp fibres. The percentages of NaOH concentration can be calculated using equation 1

$$\%\text{Concentration} = \frac{\text{weight of Solute}}{\text{Volume of solution}} \times 100 \quad \ldots\ldots(1)$$

OPMF + NaOH + H_2O ⟶ Alkaline metal salt of fatty acids + Monosaccharide units

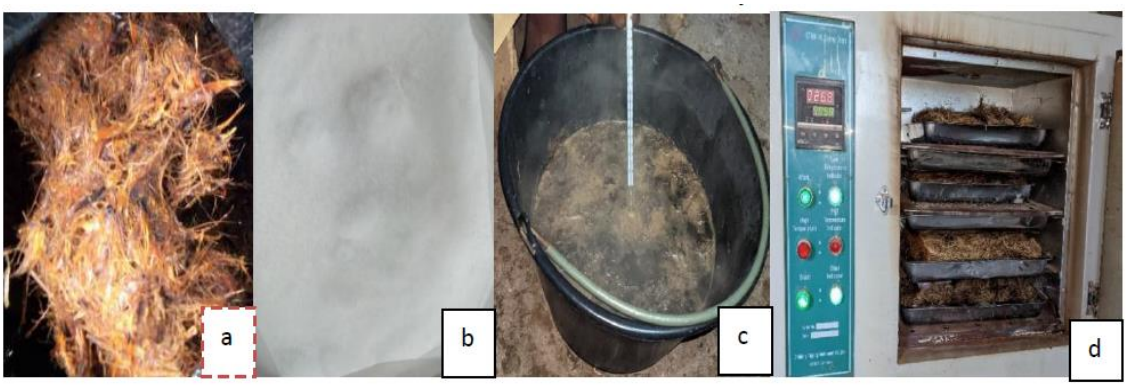


Figure 1 **(a) Wet mesocarp (b) NaOH (*c*) Temperature measurement (*d*) Oven drying.**

2.2. Determination of chemical content of mesocarp fibre

In order to determine the Chemical composition of mesocarp fibres a series test were carried out on the fibres, such as lignin content, cellulose, hollocellulose, moisture content, water absorption, hemicellulose, dewaxing.

2.2.1. Moisture content

The gravimetric method in a muffle furnace was used for moisture content determination.[21] 2.33g of OPMF was measured using an electronic balance of precision 0.01 and recorded as W1, the sample was Oven dried at 105°C for 24hours. It was then remove from the oven, reweighed (W2) and allowed to cool at room temperature in a desiccator. Figure 2 a and b illustrate the weighing and oven dry of the samples for moisture content determination.

Figure 2 a) weighing of OPMF b) oven drying of OPMF.

The moisture content percentage was calculated using the formula

$$\%\ Moisture\ content = \frac{W1-W2}{W1} \times 100 \quad \ldots\ldots (2)$$

2.2.2. Water absorption

It was performed according to the method[22], where three samples of mass 6.35g, 6.14g and 6.61g were measured and put in 3 beakers. Distilled water was added to the beaker to

completely soak the fibres. The samples were allowed in water for 24hours and then removed and placed on a filter paper for excess water to be removed completely. The samples were weighed again and the wet weight taken. Figure 3 a and b illustrate the water absorption process of OPMF.

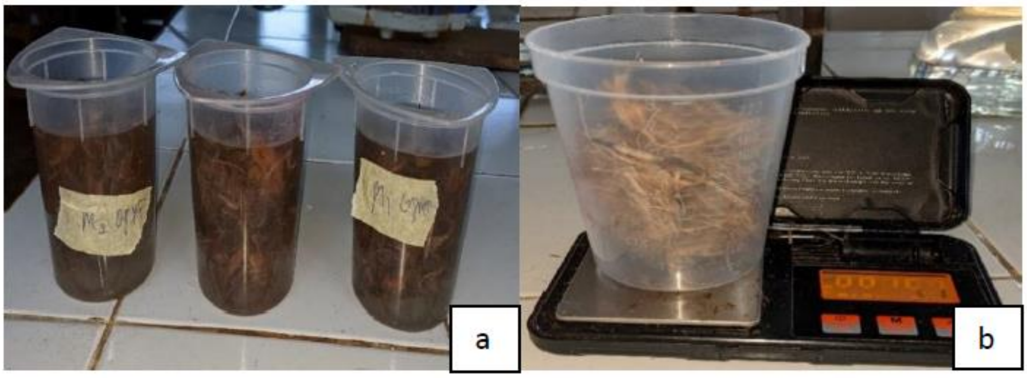


Figure 3 a) OPMF dissolved in 3 beakers of H_2O b) weighing of OPMF.

The water absorption percentage was calculated using the formula

Water absorption (%)= $\frac{\text{Wet weight} - \text{dry weight}}{\text{dry weight}} \times 100$……………………………………(3)

2.2.3.De-waxing

This was done following the method[23] through the Meceration process which involved softening of fibres by soaking it into a liquid ethanol for 4h and filtering with the help of a filter paper. This substrate obtained is subsequently introduced into soxhlet apparatus to enable the separation of ligin, pectin, cellulose and other compound contain in the fibres.

The fibre was chopped into pieces and placed in a thimble made of filter paper. The thimble containing the fibre was then placed in a soxhlet extractor, which is a close glass apparatus consisting of a boiling flask, a reflux condenser and a siphon that connects the boiling flask and the condenser. Ethanol was added to the boiling flask and heated to boiling. The vapor from the boiling solvent rises up through the siphon and condenses on the walls of the condenser, forming droplets that fall back in to the boiling flask. As the solvent condensed and fell back into the boiling flask, it dissolves some of the oil from the fibre in the thimble. The dissolved oil then travels back up the siphon and it is collected in the condenser. The process continued for 4hours until the oil was completely extracted from the fibre. The collected extract was then separated from the solvent and futher processed

$$(C_6H_{10}0_5)n + nC_9H_{10}O_2 + nC_9H_{10}O_2 \longrightarrow \text{dissolved lignin + cellulose}$$

(Cellulose) + (lignin) + (ethanol) ⟶ dissolved lignin + cellulose

Figure 4 a, b and c illustrates the de-waxing processes of OPMF.

Figure 4 a) Maceration process of OPMF b) Filtering of and Preparation for soxhlet process c) Soxhlet extractor.

2.2.4.Lignin test

This was done following the Kalson method.[21] 1g(W0) of OPMF from the soxhlet process was treated with 1% NaOH and dried in the oven for 24hours it was then removed and Placed in a beaker and 15mls 72% Sulphuric acid (H_2SO_4) was added then kept in the fridge for 5mins to acquire the fridge temperature while soaking. It was later removed and kept at room temperature for 2hours. It was then transferred into a reflux setup and 510mls of H_2SO_4 added and refluxed for 4hours at 95^0c. During this time, the acid breaks down the cellulose and hemicellulose leaving behind the lignin. After 4 hours, the sample was cooled at room temperature and distilled water added to dilute the acid. The sample was filtered using a pre-weighed crucible (W1) washing the residue with distilled water to remove any remaining acid. The residue was dried in an oven at a specified temperature of 103^0c for 2hours. The crucible containing the dry residue was weighed (W2). Figure 5 illustrate the process of determination of lignin content of OPMF

The lignin content can be calculated using the equation (4)

$$\text{Lignin content (\%)} = \frac{W2 - W1}{W0} \times 100 \quad \ldots\ldots(4)$$

$(C_6H_{10}0_5)n$ cellulose + nH_2SO_4 Sulphuric acid ⟶ $n(C_6H_{10}0_5$ (glucose) + H_2O(water) + (n- 1) H_2SO_4

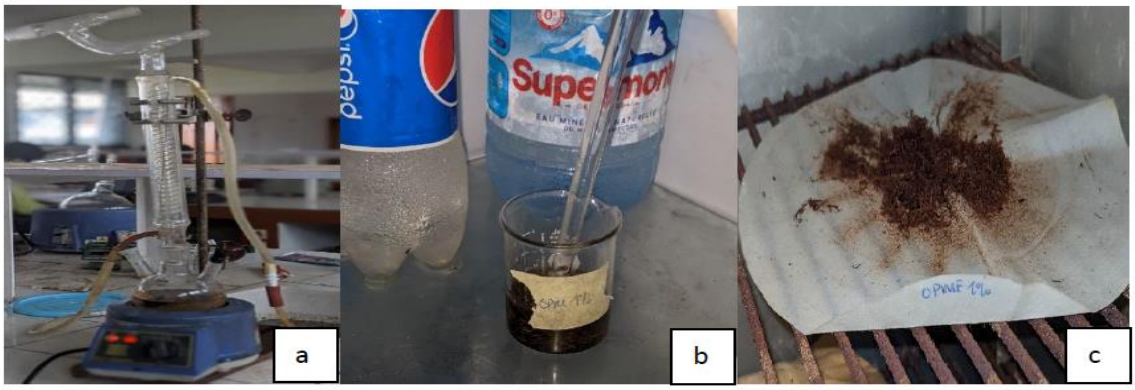


Figure 5 a) Reflux apparatus b) Distilled water added to diluted acid c) Oven drying of residue.

2.2.5.Pectin test

The test was performed according to the method[23] OPMF was dried, 3g of OPMF was weighed, and 300mls of distilled water added. The PH was adjusted to four by adding HCL into the fiber-water combination. The mixture was allowed to boil for 1hour. It was then filtered using a sieve and the fiber discarded. 200mls of ethanol was added to the precipitate and allowed.

2.2.6.Hemicellulose and cellulose determination

This was done through Neutral detergent fiber method[24], where 0.5grams (W1) of OPMF was weighed and 50mls of potassium hydroxide added. It was allowed to stay for 4hours while stirring was done every 5minutes. It was then filtered using a filter paper of known weight (W2) and 50mls of acetic acid added to rinse it and then later rinsed with distilled water. It was then dried in an oven at temperatures of 50^0c for 2hours and the dry mass recorded (W3). Hemicellulose is hollocelulose minus cellulose. Mathematical we had;

$$\%\text{Cellulose content} = \frac{\text{Cellulose Rescidue weight}}{\text{original weight}} \times 100 \quad \text{.....(5)}$$

2.2.7.Holocellulose determination

According to the Neutral detergent fiber method[24], 1.5g of OPMF was measured and put in a beaker.75mls of sodium hypochloride and 25mils hydrochloric acid added and the PH adjusted to 4. It was allowed to boil for 90minutes. 100mls of sodium metabisulphite was added and allowed to boil for 15minutes. It was then filtered using a filter paper and rinsed with cold distilled water and then dried for 2hours. Mathematically

$$\%\text{Hollocellulose} = \frac{\text{Dry weight}}{\text{Wet weight}} \times 10 \quad \text{.....(6)}$$

2.3.Physio-mechanical characterization of the soil

The soil used in this research was obtained from mile 5 junction Nkwen in the North west region of Cameroon. Soil samples were taken at the 150 cm depth of soil profile to avoid a mix with soil organic matter. The various test carried out on soil include: moisture content, water absorption, specific gravity, liquid limit, plastic limit, cigar test, organic content, proctor test, acidity test.

2.3.1.Determination of moisture content of the soil: Dying method[25]

Three cans labelled 57, 68 and 59 were dried and weighed (W1). Specimens were placed in the pans and weighed (W2). The pans were then kept in the oven for 24hours at a constant temperature of 105^0c. After 24hours, the final constant weight (W3) of the pans with dried soil sample was recorded. This method[25] was based on removing soil moisture by oven drying a soil sample unstill the weight remains constant. The moisture content (%) was calculated from the sample weight before and after. Figure 6 a and be shows the weighing the various soil samples.

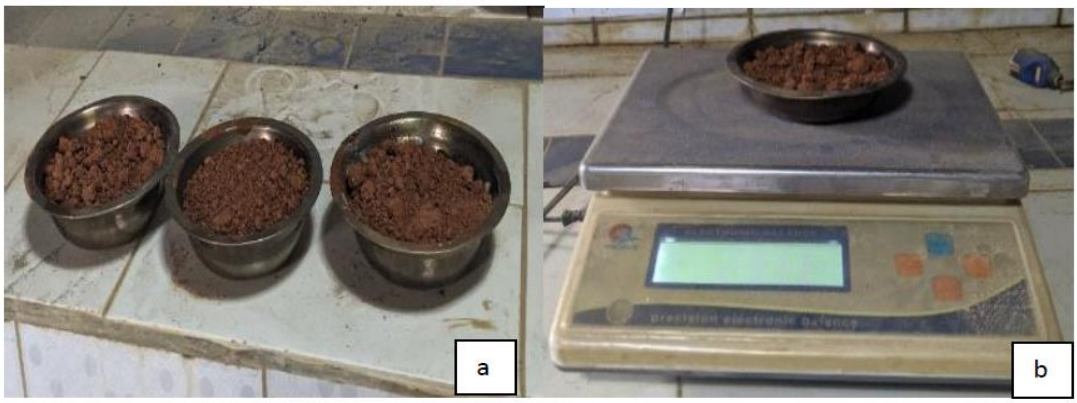


Figure 6 a) Soil samples b) Weighing of the various samples.

2.3.2.Determination of specific gravity[26]

Two picnos P1 and P2 were dried and weighed and their weights labelled W1 and W2. Water was put half in the picno cylinders and weighed. The soil sample was weighed using a scale balance. The soil sample was then put in the picno cylinder and shaked to avoid voids. It was then kept for 24 hours. After 24 hours, water was filled up to 500ml and then weighed. The same procedure was done for both picno cylinders. Figure 7 a and b shows specific gravity determination process.

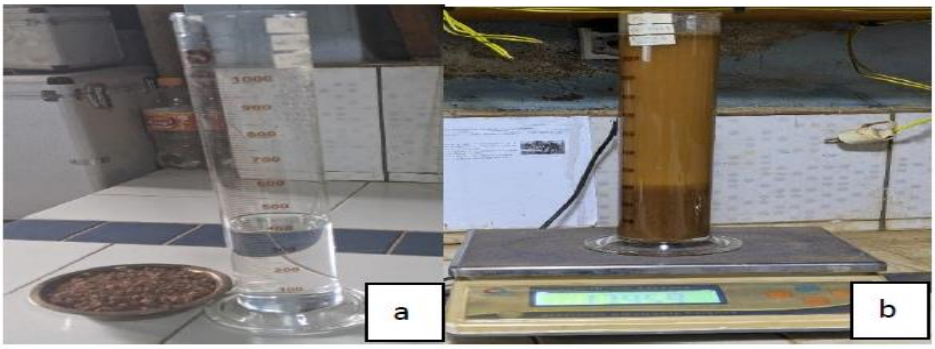


Figure 7 a) Soil Sample and Picno cylinder b) Weighing of the Soil and Solvent content.

2.3.3.Determination of Atterberg's limit tests[27]

This test was performed to determine the plastic and liquid limits of a fine grained soil according to the Unified Soil Classification system.

2.3.3.1.Determination of liquid limit

Soil was put in water for 48hours, washed with 425microns sieve and sundried. 120g of air-dried soil from thoroughly mixed portion of material was obtained. Water was mixed to the soil using a mixing disc to form uniform paste. A portion of the paste is placed in the cup of Liquid Limit device and spread into portion with few strokes of spatula. It was then trimmed to a depth of 1cm at the point of maximum thickness and excess of soil returned to the dish. The soil in the cup was divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension was formed. The cup was lifted and dropped by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only. The number of blows required to cause the groove close for about 1 cm was recorded. A representative portion of soil was taken from the cup for water content determination.[27] The test was repeated with different blows between 17 and 37. Figure 8 illustrates the of Liquid Limit determination process of soil.

Fig 8 a) Casagrands apparatus (b) Samples removed for oven drying.

2.3.3.2.Determination of plastic limit

20g of thoroughly mixed portion of the soil passing through 425-micron sieve was measured, mixed thoroughly with water in a dish until the soil mass became plastic enough to be easily moulded with fingers. It was Allowed to season for sufficient time for 2hours to allow water to permeate throughout the soil mass. 10gms of this plastic soil mass was rolled between fingers and glass plate with just sufficient pressure into a thread of uniform diameter throughout its length. This Continued rolling until a threaded of 3 mm diameter was obtained. This process Continued until the thread crumbled when the diameter was 3 mm. The crumbled pieces were collected for moisture content determination as described by.[27] The test was repeated 2 times and the average of the results taken and calculated to the nearest whole number. Figure 9 a, b and c illustrate process of plastic limit determination.

Figure 9*:* a) Soil preparation for plastic limit test b) Samples to be put in the oven c) Oven drying.

2.3.4.Moisture-Density compaction test[28]

Three moulds were used. Mass of soil was put in the moulds in three layer. Each layer had to be compressed with hammer (4.5kg) for 10blows, 25 blows, and 56 blows each. Later the top mould was removed and thus the excess ground. This test was performed to determine the relationship between the moisture content and the dry density of the soil as described by.[28] Figure 10 a, b and c illustrates soil compaction and measurements for moisture density test respectively.

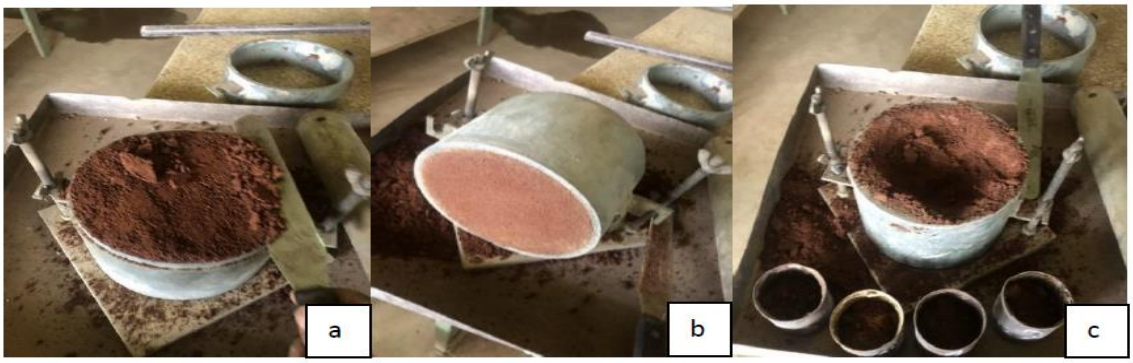


Figure 10: Modified proctor test procedure.

Soil samples were then taken from the mould to the different cans and then put in an oven at 105^0c for 24H.

2.3.5.Organic content test

The mass of the empty dry dish was measured and recorded. Soil was then placed in the dish and measured. It was then placed in the oven for 24hours at a temperature of 105^0C. It was then removed and allowed to cool at room temperature. The mass of the oven dried sample was measured and recorded. Table 6 illustrated the various measurement that were done for this test.

2.3.6.Acidity test

This test was carried out to determine the acidity or basicity of the soil. Three cans labelled P1, P2, and P3 were used. Soil was put in the cans and stirred. Litmus paper was then dropped in the soil samples and allowed there for 2hours.

2.3.7.Cigar test

The moist samples were rolled in approximately Ø 19mm then gently squeeze a small amount of soil between your thumbs and finger. The measurement of the lengths of the falling moist soil was then taken.

2.4.Mechanical and Physical characteristics of the composite

2.4.1.Determination of flexural strength

A mould of dimensions 160mm x 40mm x 40mm[29] giving a volume of 256000mm^3 was used to produce blocks for flexural strength test. The samples were produce for 1%, 2%, 3% and 4% of sodium hydroxide treatment respectively. Dry soil sample was sieved using 2mm sieve and placed in a bowl. 10% of cement and 13% of water where mixed in the soil. The mixture was placed in a lubricated standard flexural mould and compressed. Each

formulation had 10 samples produced from 0% to 2.5% fibre percentage and from 1% to 4% sodium hydroxide treatment and cured using a thick black polyethene paper for 7days, 14days and 28days respectively. The flexural testing was carried out using RMU machine serial 1461288. Figure 11 a, b c and d illustrate the flexural samples preparation and testing.

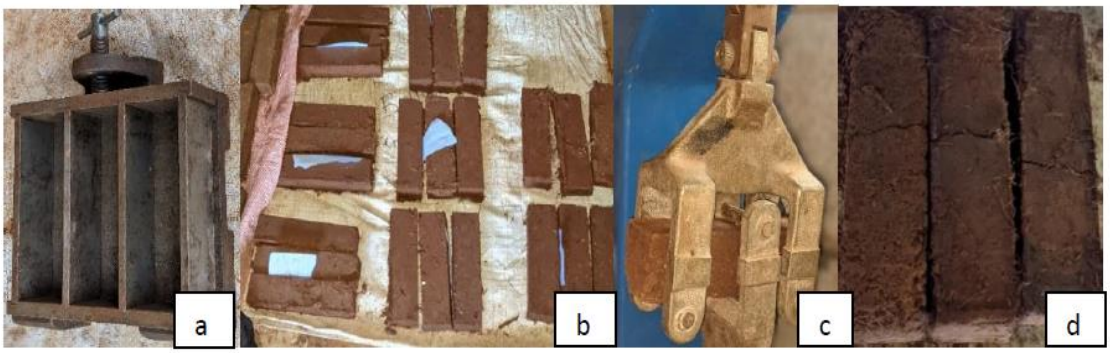


Figure 11 a) Flexural mould, b) Produced specimens (c) Three point flexural (d) Failed specimens.

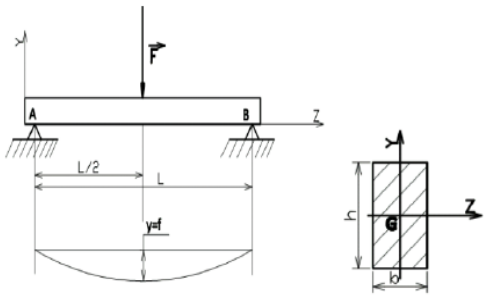


Figure 11 e) Determination of flexural strength.

$I = \frac{bh^3}{12}$; I=moment of inertia h= thickness of the specimen in mm

$F = \frac{3PL}{2bd^2}$ where F= Flexural strength of the specimen

P= Failure load in N

L=length of specimen in mm

b=Width of specimen in mm

d= height of specimen in mm

2.4.2.Determination of compressive strength

A mould of dimensions 70mm x 70mm x 70mm[30] giving a volume of 34300mm^3 was used to produce blocks for compressive strength test. The samples were produce for 1%, 2%, 3% and 4% of sodium hydroxide treatment respectively. Dry soil sample was sieved using 2mm sieve and placed in a bowl. 10% of cement and 13% of water where mixed in the soil. The mixture was placed in a lubricated standard flexural mould and compressed. Each formulation had 10 samples produced from 0% to 2.5% fibre percentage and from 1% to 4% sodium hydroxide treatment and cured using a thick black polyethene paper for 7days, 14days and 28days respectively. The compressive strength test was carried out using STYE-

2000 compressive strength machine. Figure 12 a, b and c; shows the compressive samples preparation and testing.

Figure 12 a) Samples ready for crunching b) Compressive strength machine c) Failed specimen.

2.4.3.Water absorption of cement stabilized compressed earth based-bricks

It was carried out following the protocol of[6] which involves weighing specimens and immersing them in a bath of water at room temperature. After every 2 hours, the specimens were removed and the surfaces were dried up using a dry piece of cloth for reweighing with an electronic weighing balance within a minute. This was done for 10hours. The water absorption of each specimen calculations were done as follows

$$\text{Water absorption (\%)} = \frac{\text{Wet weight} - \text{dry weight}}{\text{dry weight}} \times 100 \quad \text{.....(7)}$$

3. RESULTS AND DISCUSSION

3.1.Physical and Chemical characterization of OPMF

The results of the proximate analysis of the oil palm mesocarp fibres, water absorption and moisture content of the OPMF are presented in figure 13.

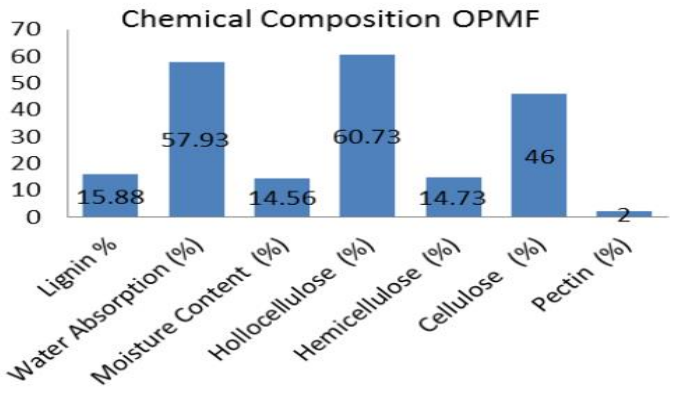


Figure 13: Chemical Composition of OPMF.

During the chemical characterization of OPMF it was observed that it contains 60.7% of hollocellulose, 14.7% of hemicellulose, 46.0% of cellulose, 15.88% of lignin, and no pectin with moisture content of 14.56% with a water absorption rate of 57.93%.

A Lignin content in OPMF of 15.88% along side absorption capacity of 57.93% can contribute to dimensional stability helps to enhance mechanical properties such improved strength, durability and resistance to deformation respectively. A similar behaviour has been observed by other authors,[31] OPMF had a moisture content of 14.56% which can help fill gaps and minimize cracking due to in construction materials there by influencing the workability of the of the fibre when used in CSEBs. High hollocelulose content of 60.73% signifies strength and durability of the OPMF. It equally indicated good mechanical properties such as strength and stiffness which are desireable in CSEBs to ensure structural integrity and longevity.[32] A high hollocellulose implies improved resistance to moisture absorption hence preventing swelling and decay caused by moisture absorption. OPMF had a hemicellulose content of 14.73% which played the role of natural binder and adhesive in CSEBs It is equally important in reinforcement and acoustic insulation. A cellulose content of 46.0% provdes stability and strength and acts as a good reinforcement fibre in CSEBs. Similar results were observed by.[33] The absence or negligible pectin in OPMF helps to improve fibre stability. This is because when pectin is negligible, it reduces the fibres suceptibility to moisture absorption and degradation. According to [34] natural fibres could be treated with NaOH in the range 2% to 5%. They treated banana fibres with 2% NaOH and discovered 0.35% to be the optimum percentage fibres addition. When OPMF is functioning as a binder, the absence of pectin can promote better compatibility between the fibre and the binderas pectin can interfer with the with bonding and adhesion between materials. According to,[12] fibers dipped in 5 % sodium hydroxide solution for 48hrs have the highest strengths. Using alkaline solution in treating, NaOH is the most preferred means for enhancing the mechanical properties of oil palm Mesocarp fibres. The use of these fibres as reinforcement in composites requires surface treatment to increase the interface bonding between fibres and matrix, consequently improving the mechanical properties of the composite.[18,35]

3.2.Physical characterization of the soil

The results of the Physical properties of the soil are presented in the Table 8. During the complete identification of the soil obtained from mile 5 Nkwen, it was observed that the soil

had a specific gravity of 2.44, plasticity index of 25.1%, organic content of 12.26%, and liquid limit of 26.7%, moisture content of 27.1%, and maximum dry density of 1.78g/cm3 (Tab.1) similar trend of results were reported by.[6] Fig 14 a, b c and d shows the liquid limit and the dry density of the soil the soil.

Table 1: Results summary of physical properties of soil.

Soil properties	Value (units
Moisture Content	27.1%
Maximum Dry Density	1.78g/Cm3
Atterbergs Limit: Liquid Limit	51.8%
Atterbergs Limit: Plastic Limit	26.7%
Plasticity Index	25.1%
Organic Content	12.26%
Acidity Test	7
Specific Gravity	2.44
Cigar Test (Ribbon Test)	7.4cm
Sedimentation Test	Sand: Clay: Silt =4.2: 1.3: 2.5
Optimum Moisture Content	19.3%

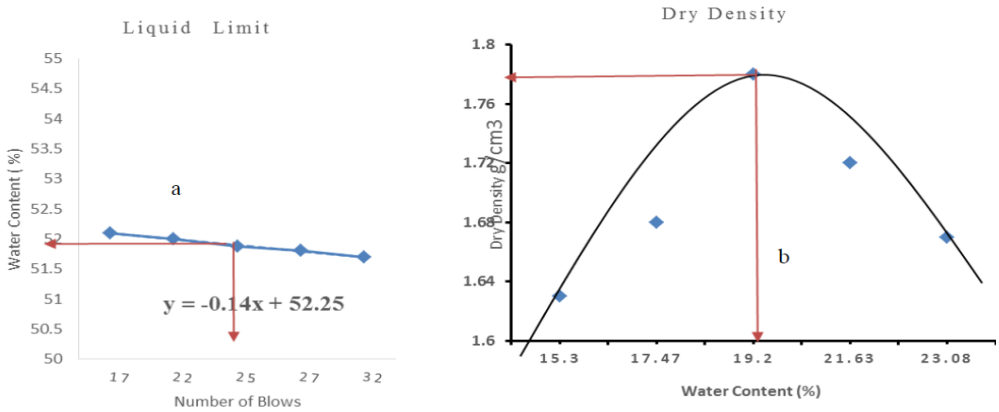


Figure14. (a) Liquid limit of soil (b) Dry density of soil.

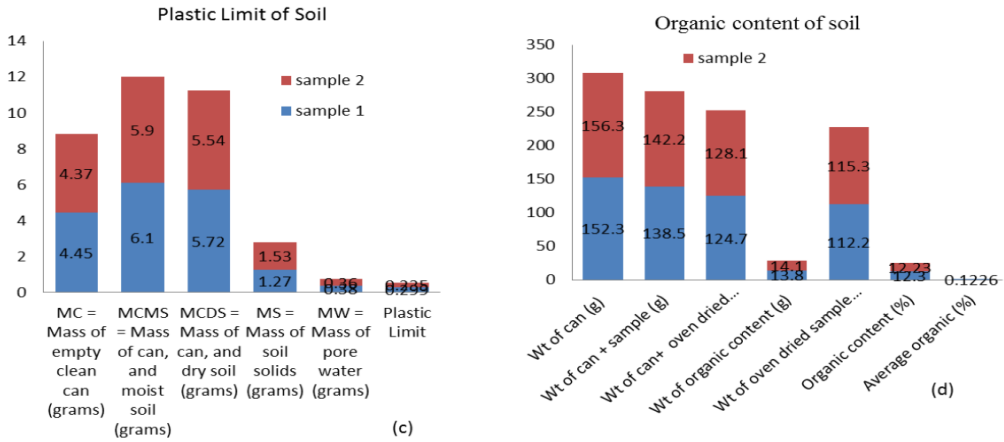


Figure 14 (c) Plastic limit of soil (d) Organic content of soil.

From figure 14 a, it was observed that at 25 drop, liquid limit of the soil was 51.8% while figure. 14 b, the maximum dry density is the measure of its compactness or density when it is at optimum moisture content. The value 1.78g/cm^3 indicates that the soil has achieved its highest density under specific compaction conditions. A liquid limit value of 51.8 % indicates that the soil requires a relatively high amount of water to reach its liquid state. Soils with liquid limit above 50 % are typically classified as highly plastic or fat soils. Highly plastic soils with high liquid limits may require additional measures to mitigate their potential adverse effects. A plastic limit value of 26.7% indicates that the soil requires a relatively low amount of water to reach its plastic state(fig.14 c). Soils with the above plastic limit are classified as low plasticity or silty soils. Soils with lower plastic limit and plasticity indexes generally have less significant volume changes and are considered more stable and easier to work with in construction. A plasticity index of 25.1% indicates a relatively high plasticity and typically falls in to a high plasticity soil category. PH of 7 Signified that the soil is neutral and it ensures compatibility and longevity of construction material. The specific gravity of soil being 2.44 is related to its density and weight. It indicates that the soil is denser than water. 7.4cm length for ribbon test signifies that the soil is sandy clay. The optimum moisture content of 19.3% signifies the maximum percentage of water that can be used for compaction. Similar observation where done by.[6,8,9]

3.3.Mechanical characterization of composite

3.3.1.Flexural strength

Table 2: illustrate average flexural strength of composite.

Curing of Composites	% Fibres in Composite	Average Flexural Strength of Composite (MPa)			
		S1	S2	S3	S4
7 Days	0	1.05			
	0.5	1.24	1.46	1.56	1.28
	1	1.31	1.58	1.5	1.46
	1.5	1.58	1.69	1.65	1.5
	2	1.76	1.89	1.83	1.76
	2.5	1.69	1.76	1.61	1.54
14 Days	0	1.13			
	0.5	1.43	1.53	1.5	1.43
	1	1.6	1.65	1.59	1.54
	1.5	1.68	1.78	1.71	1.67
	2	1.89	1.99	1.88	1.82
	2.5	1.8	1.84	1.73	1.61
28 Days	0	1.24			
	0.5	1.56	1.73	1.64	1.46

	1	1.65	1.8	1.76	1.57
	1.5	1.79	1.88	1.8	1.65
	2	1.97	2.17	1.97	1.87
	2.5	1.86	1.99	1.84	1.64

Table 3: illustrate average density of composite.

Curing of Composites	% Fibres in Composite	Average Density of Composite (g/cm^3)			
		S1	S2	S3	S4
7 Days	0	1.88	1.88	1.88	1.88
	0.5	1.86	1.83	1.87	1.83
	1	1.71	1.85	1.86	1.83
	1.5	1.68	1.81	1.85	1.83
	2	1.67	1.83	1.83	1.80
	2.5	1.65	1.81	1.83	1.78
14 Days	0	1.83	1.83	1.83	1.83
	0.5	1.74	1.80	1.85	1.81
	1	1.66	1.83	1.83	1.80
	1.5	1.64	1.80	1.83	1.80
	2	1.61	1.78	1.74	1.72
	2.5	1.61	1.70	1.71	1.68
28 Days	0	1.72	1.72	1.72	1.72
	0.5	1.66	1.74	1.72	1.71
	1	1.62	1.74	1.71	1.69
	1.5	1.60	1.74	1.74	1.69
	2	1.56	1.69	1.70	1.65
	2.5	1.56	1.64	1.65	1.65

The results of the flexural strength of the composite for 1% to 4% (S1 to S2) NaOH concentration pretreatment and 7, 14 and 28 days of curing respectively are presented in the fig 15 a, b and c

From the graphs in fig. 15 a, b and c, with S1, S2, S3 and S4 (1%, 2%, 3% and 4% NaOH Concentration), it was seen that, the maximum flexural strength was obtained at S2, for 7, 14, 28 days at 2% fibre addition. There is a gradual increase flexural strength with increase in fibres percentage from 0.5% to 2% and a drop to 2.5%. This indicates that, the maximum flexural strength of the composite was attended at 2% fibre addition .the least strength is observed at S4. This was because 4% of NaOH reduces the strength of the fibres at higher concentrations and so the best quantity of NaOH to use is 2% that is S2. Similar results were obtained by.[6]

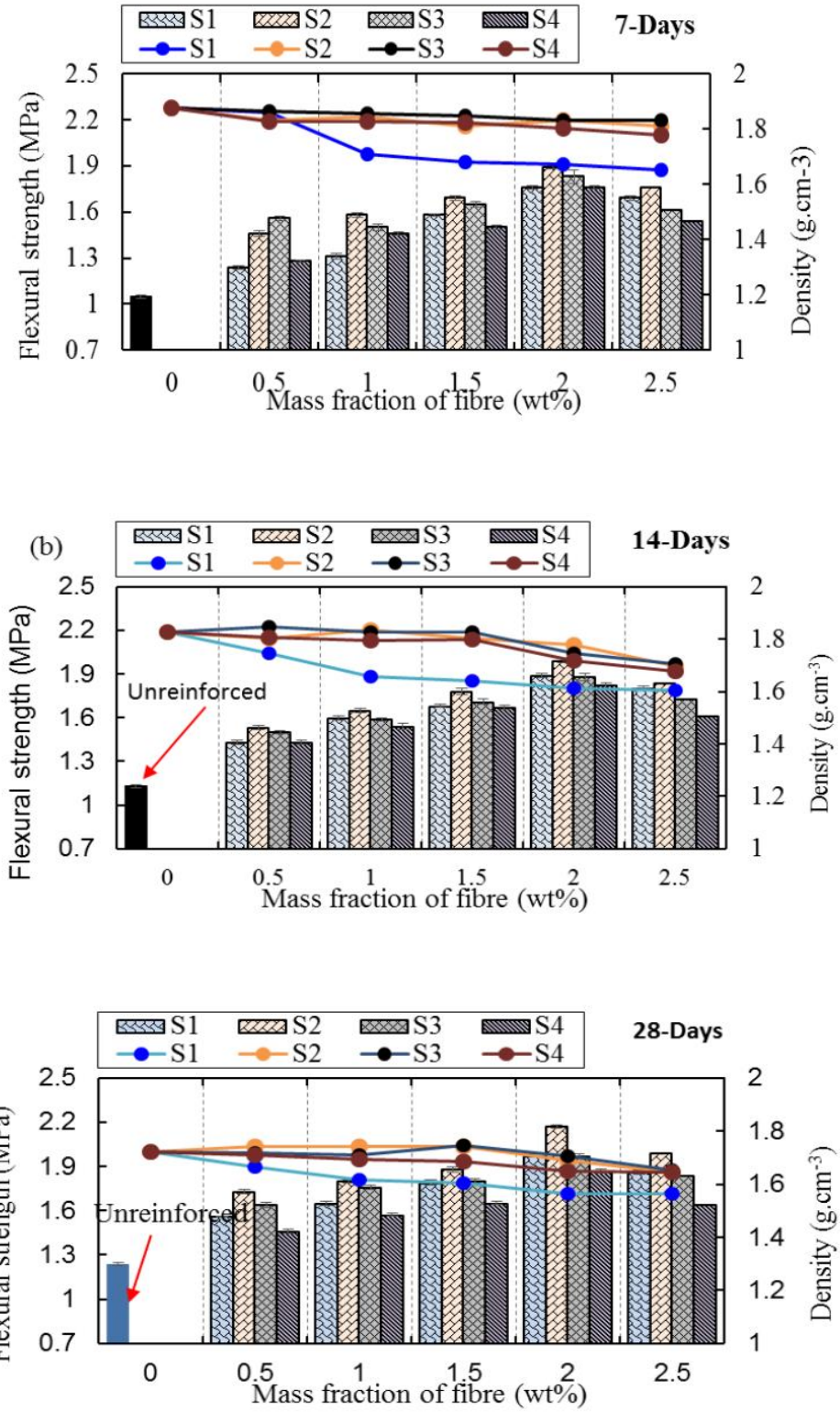


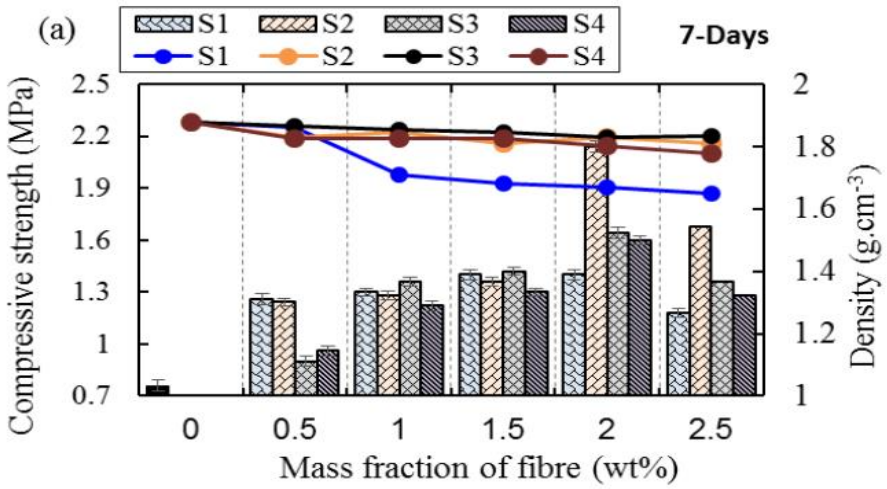
Fig. 15: Average flexural strength of composite with different NaOH concentration and days.

3.3.2.Compressive strength of the composite

Table 4: Illustrate average compressive strength of composite.

Curing of Composites	%o Fibres in Composite	Average Compressive Strength of Composite (MPa)			
		S1	S2	S3	S4
7 Days	0	0.76			
	0.5	1.26	1.24	0.9	0.96
	1	1.3	1.28	1.36	1.22
	1.5	1.4	1.36	1.42	1.3
	2	1.4	2.14	1.64	1.6
	2.5	1.18	1.68	1.36	1.28
14 Days	0	0.92			
	0.5	1.32	1.16	1.44	1.44
	1	1.52	1.42	1.7	1.78
	1.5	1.6	1.94	1.94	1.74
	2	1.74	2.4	2.1866	2.06
	2.5	1.3	1.64	1.92	1.82
28 Days	0	0.88			
	0.5	2.1	1.86	1.82	1.52
	1	2.1	2.08	2.04	1.78
	1.5	2.02	2.36	2.14	2.02
	2	2.4	2.46	2.3666	2.2
	2.5	1.5	2.14	2.22	1.82

The results of compressive strength of the composite for 1% to 4% (S1 to S2) NaOH concentration pretreatment and 7, 14 and 28 days of curing respectively are illustrated in the figure 16 a, b and c.



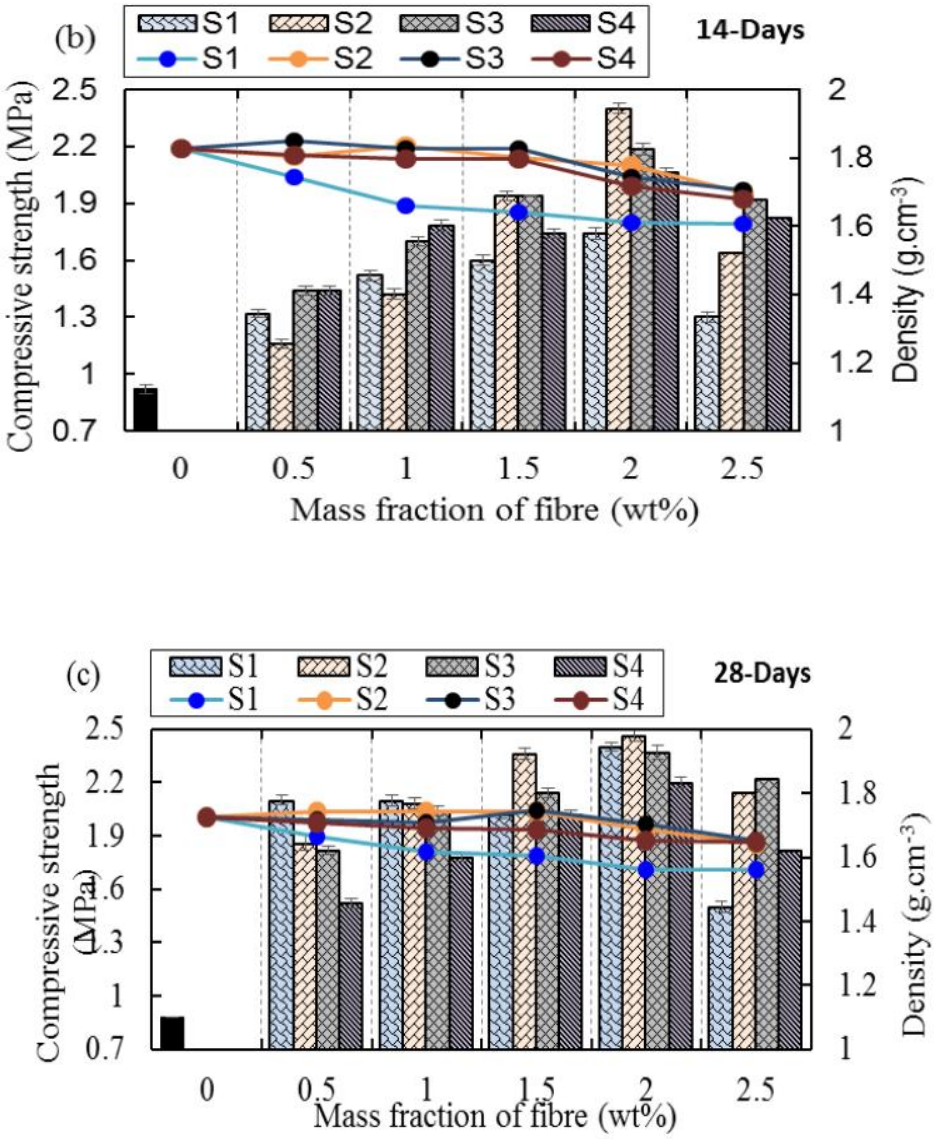


Figure 16: Average compressive strength of composite with varing NaOH Concentration and Days.

Similarly, graphs in figure. 16 a, b and c, for the compressive strength, After 7, 14 and 28days of curing, the maximum compressive strength was observed at 2% fibres addition respectively with the highest strength yield of 2.4MPa for specimens at 2 % concentration of sodium hydroxide fibres treated for 28days curing. A similar result was observed for studies of.[6]

The average density of the composite were illustrated by the curves shown in figure.15 and 16 a, b and c respectively. It was observed that the composite with the highest densities were those obtained at 7 days curing while the lowest density were at 28days. For the 28day

specimens lowest densities were at 2.5% of fibers concentration in the composites, for fibers pretreatment (NaOH concentration S1, S2, S3 and S4 respectively). Highest densities were noted for the 7day at 0% fibre due to the high density of soil and the moist nature of the of specimen at this stage due to incomplete cementation of the samples similar result where observed by.[36]

3.3.3.Water absorption

Table 5: Average water absorption of composites.

% NaOH concentration	% Fibres in composite	Average water absorption of composites (%) with time				
		2hours	4hours	6hours	8hours	10hours
S1	0	8.2	8.6	8.8	9.2	9.2
	0.5	9.4	9.9	10.2	10.4	10.4
	1	10.5	10.5	10.9	11	10.9
	1.5	11.3	11.5	11.7	11.9	11.9
	2	12.1	12.4	12.6	12.7	12.7
	2.5	12.7	12.8	13.2	13.2	13.2
S2	0	8.2	8.6	8.8	9.2	9.2
	0.5	9.2	9.5	9.8	10	10
	1	9.4	9.8	9.9	10.3	10.3
	1.5	10.3	10.6	10.7	10.8	10.8
	2	11.1	11.3	11.5	11.7	11.7
	2.5	11.4	11.7	12.3	12.7	12.7
S3	0	8.2	8.6	8.8	9.2	9.2
	0.5	8.7	8.9	9.2	9.5	9.5
	1	9.3	9.4	9.6	9.9	9.9
	1.5	10	10.4	10.5	10.6	10.6
	2	10.6	10.8	11.1	11.2	11.2
	2.5	11.2	11.4	11.5	11.6	11.6
S4	0	8.2	8.6	8.8	9.2	9.2
	0.5	8.7	8.8	8.9	9.3	9.3
	1	9.2	9.4	9.5	9.6	9.6
	1.5	10	10.2	10.3	10.4	10.4
	2	10.2	10.4	10.5	10.6	10.6
	2.5	10.9	11.2	11.4	11.5	11.5

Result of water absorption for composite derived after 28days of curing from flexural samples for different formation of fibres and NaOH concentrations (S1 to S4) are illustrated in fig figure a, b c and d respectively.

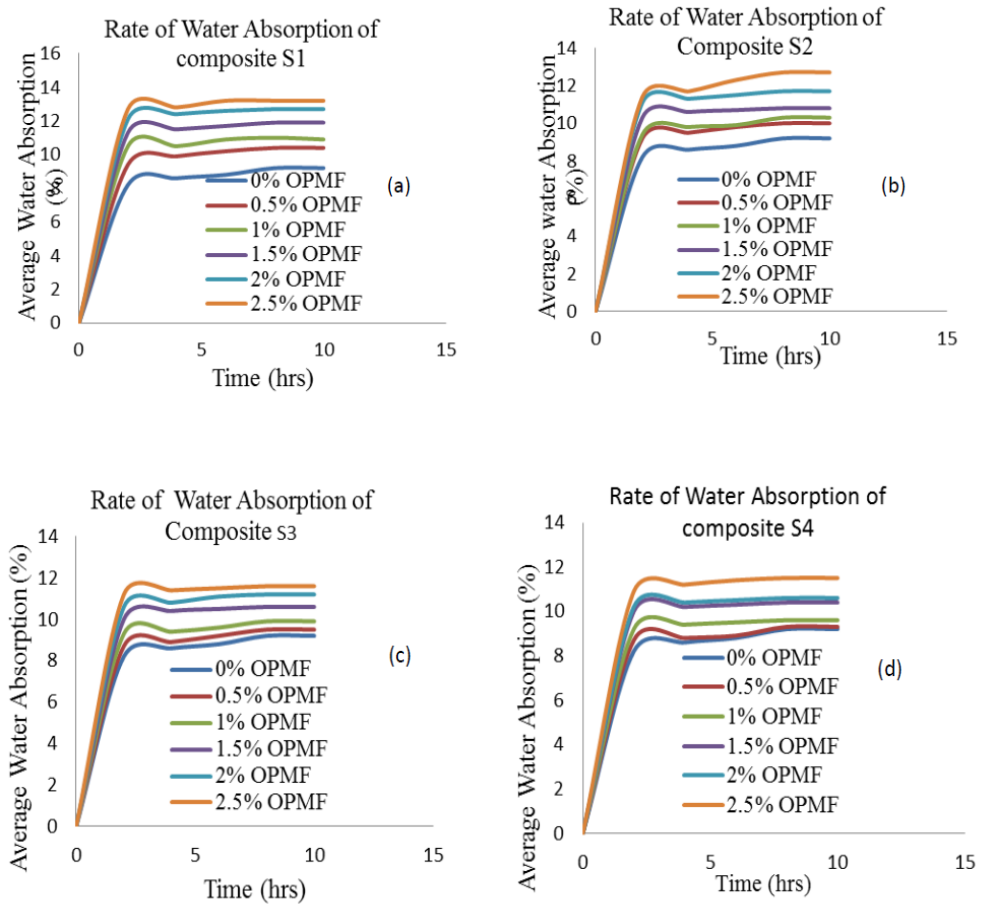


Figure 17: Rate of water absorption of composite at 28days of curing (a) 1% NaOH fibres pretreatment (b) 2% NaOH fibres pretreatment (c) 3% NaOH fibres pretreatment (d) 4% NaOH fibres pretreatment.

Form the graphs shown in figure.17 a, b, c and d, it was observed that there was a general increase in the amount of water absorption with the addition of fibres from 0.5% to 2.5% for S1 to S4 up to a saturation period of 8hours. The samples in figure.17 a (S1) showed the highest water intake of 13.2% while the figure.17 d (S4) showed the lowest water absorption rate of 11.5%. This is because higher alkaline pretreatment fibres enhance the hydrophobic nature of fibres present in the composite. Similar observations were obtained alkaline pretreatment of stalk and spikelet fibres from oil palm by.[6]

CONCLUSION

In order to enhance the mechanical properties of CSCEB, an investigation on the effects alkaline pretreatment of OPMF on the mechanical characteristics of cement stabilized compressed earth blocks in building construction was carried out. It was observed that, the use of alkaline (NaOH) pretreatment from 1% to 2% concentration for OPMF and gradual

addition of fibres in the composite from 0.5% to 2% content respectively displayed a gradual increase in compressive and flexural strengths for the 7, 14 and 28 days of curing respectively while at 3% to 4% NaOH concentration and 2.5% fibres content in the composite, compressive and flexural strength drops. This drop in mechanical properties of the composite at 2.5% fibres content could be explained by fibres saturation within the composite which weaken the adhesive bonding between the fibres and soil the molecules. Composites at 7 days of curing had the highest densities and the least compressive and flexural strengths while those cured for 28days had the least density and highest compressive and flexural strengths. The composite equally attained water saturation after 8hours hence, samples obtained after 28days of curing which had gone alkaline pretreatment of OPMF with 2% NaOH concentration and contain 2% fibres in composite were the most preferable for applications in building construction blocks.

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Author's Contribution

Noubissie Tchoko Romuald loic: data collection, interpretation of result, drafting, and reading of manuscript, Yakum Reneta Nafu: supervision of work, methodology, validation of test and reading of manuscript Betene Ebanda Fabien: supervision of work, validation of test and reading of manuscript, Tatah Fabiola Kewir: data collection and reading of manuscript, Foba Josepha Tendo: supervision of work, methodology and reading of manuscript.

Statements and Declaration

The authors declare that they have not known competing financial interest or personal relationship that could have appeared to influence in the paper.

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