ISSN: 2456-8651

International Journal of Engineering Science Technologies
November-December 2020, Vol 4(06), 30 – 38
DOI: https://doi.org/10.29121/IJOEST.v4.i6.2020.128

INFLUENCE OF MECHANICAL AND PHYSICAL PROPERTIES OF PALM NUT SHELL- PLASTIC COMPOSITE

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DOI: https://doi.org/10.29121/IJOEST.v4.i6.2020.128

Article Type: Research Article

Article Citation: Yakum Reneta Nafu, Wannyuy Kingsly Mofor, and Ngwe Nnoko Ngaaje. (2020). NFLUENCE OF MECHANICAL AND PHYSICAL PROPERTIES OF PALM NUT SHELL- PLASTIC COMPOSITE. International Journal of Engineering Science Technologies, 4(6), 30-38. https://doi.org/10.29121/IJOEST.v4.i6.2020.128

Received Date: 26 October 2020

Accepted Date: 20 November 2020

Keywords:
Palm Kernel Shell
Polyethylene
Particle Size
Composites
Flexural
Compressive Test
Density
Water Absorption
Pollution

ABSTRACT

Increasing population levels, booming economy and rapid urbanization have greatly accelerated the municipal solid waste (MSW) in our country; in our cities (Bamenda, Buea, Douala, Yaoundé etc.), poor management of solid waste constitutes an urgent problem: flood, deterioration of the urban environment in the form of air, water, and land pollution. Options like recycling and material recovery for subsequent re-use present enormous opportunities for waste management with economic and ecological benefits, wastes as well as plastic and palm nut shell have not yet been recycled satisfactorily; the performances of palm nut shell-plastic composites of 30% palm kernel shell with particle sizes varying from 1mm to 5mm and 70% of polyethylene were used to produce different samples The effects of palm kernel shell particles' size on mechanical and physical properties of the new composite were studied by the help of different mechanical (flexural and compressive test) and physical tests (density and water absorption). Results showed a better interaction of polyethylene and palm kernel shell particles at 1mm sieve with compressive stress and water absorption higher at 1mm, ultimate flexural stress and the young's modulus of the material increased as the particle size of the palm kernel shell increased, relatively higher density were obtained at 3mm of the palm kernel shell (PKS) size.

1. INTRODUCTION

The increasing amount of Municipal Solid Wastes (MSW) in our country presents greater challenges with respect to proper and sustainable solutions to manage such generated waste [1]. With the increasing population and economic activities and also the rapid changing of lifestyles, Cameroon like many other countries, is faced with greater challenges towards managing solid waste. Options like recycling and material recovery for subsequent re-use present enormous opportunities for waste management with economic and ecological benefits. In recent years, with growing environmental awareness, agro-fillers (agro-based waste) are now increasingly used as reinforcing fillers in thermoplastic composite materials [2], [3] Industries, shop, super market, hostel and others generate significant amount of waste of which some are recyclables. One of the most effective methods that can be applied to get rid and save the world form the environmental pollution was demonstrated by Mehdi Seghiri *et al*. (2017) [4] with the mechanical properties of sand and plastics composite which was possible to manufactured roof tile from recycled plastic and sand dune. In Municipal Solid Wastes generated within Cameroon; plastics, paper, palm nut shell and ferrous/nonferrous metals occur is significant amounts that serve as a pointer in investigating possibilities for recycling and recovery of such components, the increasing amounts of MSW which is fast attracting the attention of researchers and the government, requires that appropriate sustainable solutions be find out. The use of waste plastics in the concrete give a good advantage to reducing the weight of it with lower compressive strength and tensile strength. [5], [6], [7], [8], [9]

As economic benefit, the use of biomaterials in general and agro-waste in particular is a subject of great interest nowadays not only from the technological and scientific points of view, but also socially, and economically, in terms of employment and cost [10] Cameroon is endowed with a lot of mineral and agro-based resources that could be used in the development of environmental- friendly composite materials.

A number of automotive components previously made with glass fiber composites are now being manufactured using environmentally friendly composites. This may be attributed to low-weight ratio of the composites [3]. Thousands of tons of different crops are produced but most of their wastes do not have any useful utilization. The disposable component of harvested agricultural product (palm kernel) and low-density polyethylene are becoming increasingly problematic in Cameroon, littering the rural and urban areas of the country, and constituting a serious threat to environmental health of the nation [11].

Mechanical properties of plant fibers are much lower when compared to those of the most widely used competing reinforcing glass fibers. However, because of their low density, the specific properties (property-to-density ratio), strength, and stiffness of plant fibers are comparable to the values of glass fibers [12], [13]

The purpose of the research is to explore the potential of using palm kernel shell to reinforces in polymer matrix composite for the development of new engineering material.

2. MATERIALS AND METHODS

Palm kernel shell (PKS) were obtained from a legally registered company in Cameroon active in the rubber and oil palm plantation industry (SOCAPALM) located at SUZA, in the littoral Region of Cameroon. The kernel shell was then grind using grinding machine and the particles size (1mm, 3mm, 4mm and 5mm) were selected using four machine's sieves. The plastic bottle, plastic paper particularly polyethylene were obtained from the Bambili locality north west region cameroon. The following specimen composition were being used

specimen	Composition
A	30% PKS (size 1mm) and 70% polyethylene
B	30%PKS (size 3mm) and 70% polyethylene
C	30%PKS (size 4mm) and 70% polyethylene
D	30%PKS (size 5mm) and 70% polyethylene

Specimens of standard dimensions (cylindrical Ø60mm, height 200mm) were cast for compressive strength determinations and prismatic specimens of (40mm x 40mm x 160mm) were cast for bending strength. All the specimens were cured for a period of 2 days before test. Each mixture had 15 samples for testing and the total samples manufactured and tested were 60

2.1. PRODUCTION OF PALM KERNEL SHELL-PLASTIC COMPOSITE

The composites were produced by melting the plastic using traditional fire, plastic's temperature was controlled with a thermometer (TPM-10) and the melting point was 133°C; at the melting point, the kernel shell was added and mixed to obtain a paste. The mixture was then poured into different mould and allowed to cool at ambient temperature for 48 hours before unmoulding.

Figure 1: samples in melting state

Figure 2: Specimens unmold

2.2. COMPRESSION TEST

The compressive test was carried out using RMU machine, serial 121288 in the civil engineering laboratory at the Government Technical High School BAMENDA the hydraulic machine press was consistently applied on the specimen till failure occur to obtain the maximum load.

The compressive strength was calculated from the maximum load recorded before failure, by.

Compressive strength = $\frac{F_C}{A}$ Where:

Fc: force measured from the compression test machine in N

A: area of the composite specimen in mm2

Figure 3: Specimen on compressive load and failure

2.3. FLEXURAL TEST

The test was conducted considering the **3-point ASTM standard** using RMU machine serial 1461288. The maximum stresses absorbed were noted and recorded

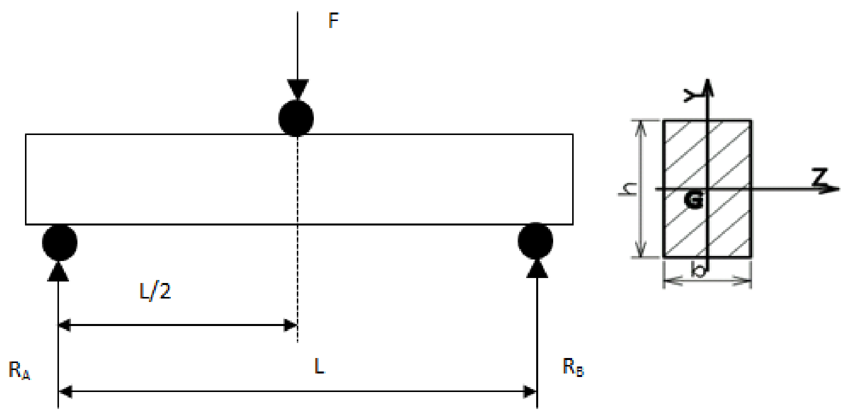

Figure 4: 3 point bending test

Figure 5: flexural testing machine

2.4. WATER ABSORPTION TEST

For water absorption (WA) test, the composites were weighed (W1) before immersing in distilled water at room Temperature. After every 4 hours, the samples were removed and the surfaces were dried up using a dry towel and weighed again (W2). The water absorption (WA) test samples were carried out for 2 days each when all were at the saturation point. The rates of water absorption of each specimen were calculated as follows:

Rate of Water Absorption (WA) = $\frac{W2-W1}{W1}\times 100$

2.5. YOUNG'S MODULUS TEST

The Young's modulus is determined by determining the maximum deflection of each sample, one end of the sample is embedded in the flat wood and the force is applied at the other end of the sample with a jack (cantilever), the deflection is then measure with a die gauche indicator, having the deflection, the young's modulus is calculated by applying the formula:

Young's modulus= $\frac{Pl^3}{3yI_{GZ}}$

Where:
P= maximum flexural load
L= length of the sample
I= quadratic moment about z axis
Y= deflection

3. RESULTS AND DISCUSSION

3.1. CALCULATION OF COMPRESSIVE STRENGTH AND STATISTICAL ANALYSIS

Averages compressive stress were obtained from 1mm to 5mm PKS sizes. It was observed that between 1mm and 2.5mm there is a rapid decrease in compressive stress of our composite, between 3mm and 5mm the stress variation become very low, the compressive stress can be reinforced by reducing the particle size of the palm kernel shell. This is due to poor adhesion between the matrix and the reinforcement. Figure 6 represent the evolution of compressive strength with respect to the palm kernel shell sizes.

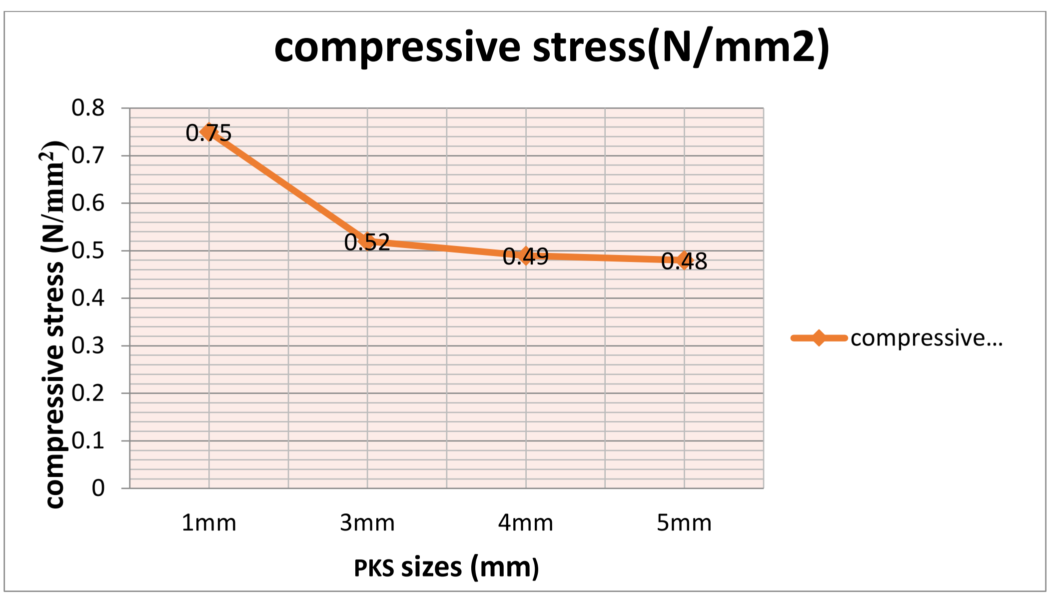

Figure 6: compressive strength vs. PKS sizes

Table 1: summarized result of compressive test

specimen	Maximum Compressive load(N)	Area (mm^2)	Compressive stress(N/mm^2)
Average specimen A	2133.33	2827.2	0.75
Average specimen B	1480	2827.2	0.52
Average specimen C	1628.33	2827.2	0.49
Average specimen D	1383.33	2827.2	0.48

3.2. DENSITY

Figure 7 reveals that contents the density of the composite that observed significant increase firstly as the particle size of the PKS increase, reaching the maximum density 0.852g/cm^3 at 2mm, then drops from 2mm until 4mm and become constant from 4mm until 5mm. This is due to the present of void in the composites.

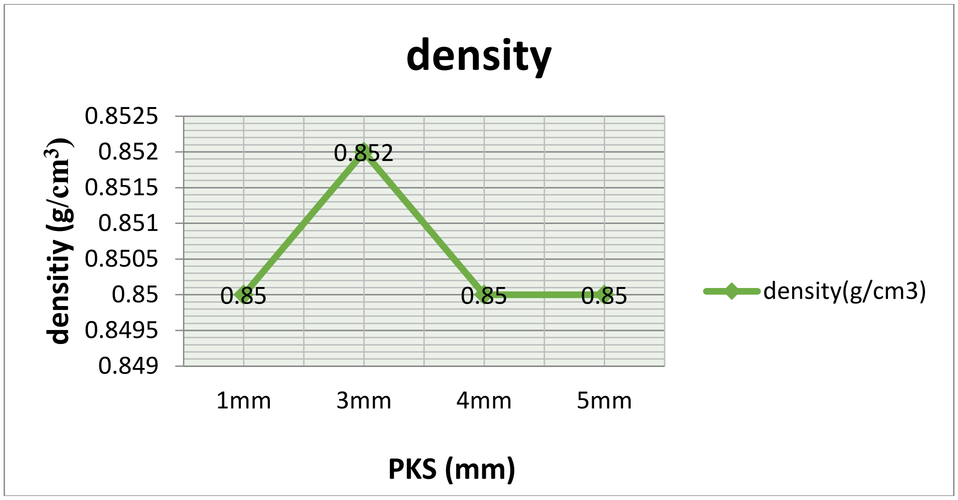

Figure 7: densities of palm kernel shell-plastic composites

3.3. FLEXURAL TEST RESULTS ON PALM KERNEL SHELL-PLASTIC COMPOSITES

$$\sigma f = \frac{3p \times l}{2 \times b \times d^2}$$

15 samples tested for flexural showed that the stress increase with the particle seizes of the PKS, contrary to the compressive strength, the flexural stress can be improved by increasing the particle sizes of the palm kernel shell; the maximum stress 0.44 N/mm^2 is obtain at 5mm as presented in Figure 8

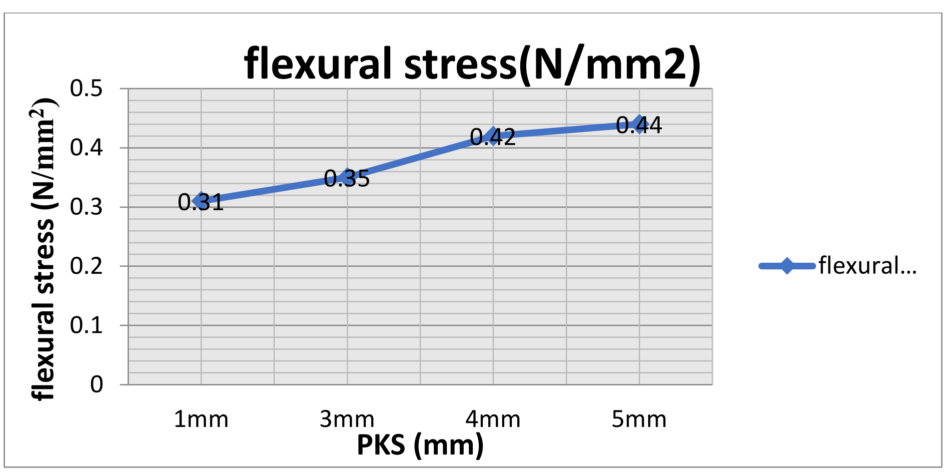

Figure 8: Plot of flexural stress against the PKS size

Results of young's modulus for palm kernel shell-plastic composites were presented on figure 9.

Resulted present showed a variation of the young's modulus with respect to the particle size of the palm kernel shell; hence we observe that the young's modulus of the material increases with the size of the palm kernel shell; the maximum young modulus 1754 N/ mm^2 is obtain at

5mm size of the PKS

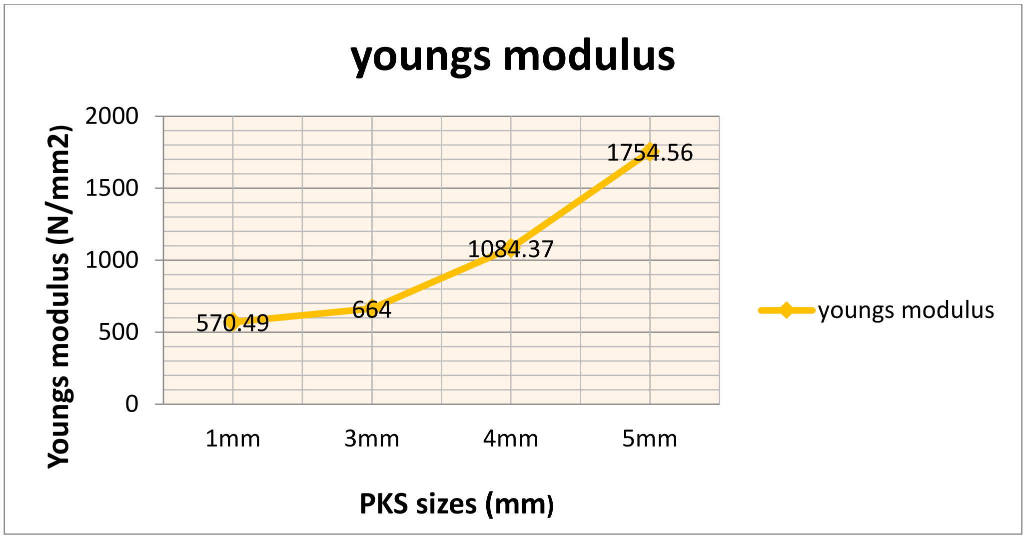

Figure 9: Plot of Young's modulus against the PKS size

3.4. WATER ABSORPTION

The water absorption rate is higher as seizes of PKS increases; the higher the particle size, the more the water absorption rate, this is possible due to high porosity cause by the large size of the kernel particles.

The minimum water absorption rate at 1mm sizes of PKS is attributed to good interfacial adhesion while the maximum water absorption rate was due to the poor adhesion between the matrix and the reinforcement [14]

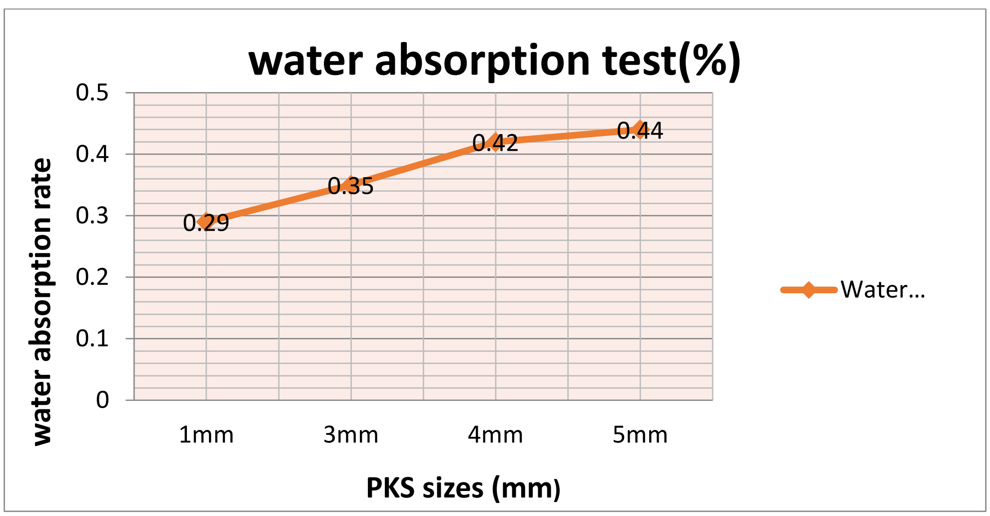

Figure 9: Plot of water absorption rate against the PKS size

4. CONCLUSION

Our study aims at the influence of different particle sizes of palm kernel shell on the mechanical and the physical properties of palm kernel shell-plastic composites. The results of the investigation show the possibility of using different palm nut shell particles as reinforces in composites production. The mechanical and the physical properties were found to be influenced by the particle sizes,

The following conclusions can be stated from the findings of the investigations:

1) The compressive stress decrease when the particle size of the PKS increase and the minimum stress 0.48N/mm^2 occur at 5mm size of the PKS.
2) The flexural stress increase with the particle size of the PKS and the maximum stress 0.44 N/mm^2 is obtained at 5mm of the particle size of the PKS.
3) The percentage of water absorption increase with the PKS size.
4) The maximum density 0.853 occur at 3mm size of the PKS, the density of the composite firstly increases as the particle size of the PKS increase, reaching the maximum density 0.852 at 2mm, the density drops from 2mm until 3.5 mm and become constant from 3.5mm until 5mm.
5) The young's modulus of the material increases with the particle size of the palm kernel shell and the optimum value obtain is 1754.56 N/mm^2 at 5mm size of the palm kernel shell.

SOURCES OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The author have declared that no competing interests exist.

ACKNOWLEDGMENT

We would like to thank the Government Technical High School Bamenda, Cameroon where the experimental works Were performed.

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