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THE INFLUENCE OF POST-CRACKED EXPOSURE PERIOD ON SOME PHYSICAL PROPERTIES OF PALM KERNEL SHELLS

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ABSTRACT

A series of experiments were conducted to measure the influence of the duration of exposure to inclement weather after cracking on the bulk density, solid or true density, porosity, and water absorption characteristics of palm kernel shells (PKS).

The results showed that the bulk and true densities decreased respectively from 0.60g/cm^3 and 1.37g/cm^3, for freshly cracked shells to 0.53g/cm^3 and 1.25g/cm^3 for shells that have been exposed to inclement weather for over ten years after cracking. The porosity and ability to hold moisture increased with the duration of exposure.

These experimental observations are attributable to the organic nature of the shells as a result of which there is a gradual biodeterioration especially of the adhering fibres. This reduces the dry matter content and increase the void. Density values obtained are comparable with other materials of construction such as earth and wood which is an indication that PKS has potentials for use as a material for construction. Further work on the mechanical properties of the material is recommended.

INTRODUCTION

The increasing demand for structures on the farm has put a lot of pressures on the materials of construction available in Nigeria. Some of such materials include wood products, clay, sand, gravel, bamboo, asbestos and cement. Most of these materials are now very expensive and beyond the reach of the rural farmers. For this reason, it has become necessary to source for alternative ones that will be suitable and affordable.

Several factors are taken into account when selecting a material for constructional purpose and such relevant factors include availability, durability, ease of working, economy and the engineering properties (Bengtsson and Whitaker,1986).

With the above-mentioned factors in mind, a new material of construction, Palm Kernel Shell (PKS) is being considered. PKS is an agricultural waste product obtained in the process of extracting oil from the mesocarp and removing the seed (kernel) from an oil palm fruit. It is available in abundance in the South and Middle belt regions of Nigeria where the climate and soil conditions favour the cultivation of oil palm.

Prior to the use of a new material for constructional purpose, the properties of such a material needs to be determined. This in effect gives a clear indication on the possible behaviour of the material under load, the depreciation rate and the life span of the structure fabricated from it. The properties of the material will eventually determine the comfort of the man, animals and other agricultural products that may occupy the structure.

The influence of age on the physical properties of any organic material intended to be used for construction cannot be over-emphasized as this will determine the safety of the structure over a period of years and the possible cost of maintenance or replacement period.

This paper discusses the influence of the duration of exposure to inclement weather after cracking on the density, porosity, and water absorption characteristics of palm kernel shell.

MATERIALS AND METHODS

Collection of Samples and Equipment

The palm kernel shell used for this research work is the dura variety which is the most abundant variety in the South-west of Nigeria. The shells used were obtained from various locations in Ise-Orun Local Government Area of Ekiti State, which is a major oil palm producing area in South Western Nigeria. From each location, three samples freshly cracked and those that have been exposed to weather after cracking for over five and ten years respectively were collected. The particle size distribution of the samples used for the experiments were almost the same. The major equipment used for the experiments were electric oven, weighing balance, beakers, measuring cylinders and cans.

Measurement of Bulk Density

The bulk density of PKS was determined by filling a container of known self-weight and volume to the brim with PKS and weighing to determine the net weight of the PKS. The bulk density was calculated from the expression:

$$\text{Bulk density} = \frac{\text{Mass of PKS}}{\text{Volume of container}}$$

Measurement of Solid Density

The solid density defined as the ratio of a given mass of sample to its true volume was determined by the water displacement method. To accomplish this, a measuring cylinder was filled with water to a certain level. PKS of known weight were gradually submerged into the cylinder which was accompanied by a rise in the level of water. The difference between the two levels of water gave the volume of the PKS. The true density was calculated from the expression:

$$\text{True density} = \frac{\text{Mass of PKS}}{\text{Volume of water displaced}}$$

Measurement of Porosity

The porosity of an unconsolidated agricultural material can either be determined experimentally using the porosity tank method or theoretically from the bulk and true densities of the material. Results from both methods have been found to be in close agreement (Waziri and Mittal 1983). The porosity of PKS in this work was determined using the relationship presented by Mohsenin (1970).

i.e. $$\text{Porosity}(\%) = \frac{\text{True density} - \text{Bulk density}}{\text{True density}} \times \frac{100}{1}$$

Measurement of Water Absorption Characteristics

The water absorption characteristics of PKS, which can be predicted by the rate of change in moisture content when soaked was determined using the method presented by Shukla *et al* (1985). Six samples of equal weights of bone dry PKS were soaked in water simultaneously and at the 6th, 12th, 18th, 24th, 30th, and 36th hour from the commencement of soaking, a sample each was drained and weighed to determine the increase in weight due to water absorbed.

RESULTS AND DISCUSSIONS

Bulk Density

The bulk density of the various samples of PKS are shown in Table 1 The average bulk density decreases from 0.60g/cm^3 for a freshly cracked shell to 0.53g/cm^3 for a ten year post-cracked exposed shell. The reduction in values of bulk density can be attributed to decrease in dry matter as a result of possible deterioration of the shell. This observation appears to be true since PKS is an organic material which can be susceptible to deterioration brought about by the influence of microorganisms and other abiotic factors. The decrease in bulk density observed in PKS implies possible decrease in strength and load carrying capacity of the material with time since density is directly related to strength of a constructional material.

Table 1: Densities of PKS (g/cm^3)

Replication	Duration of post-cracked exposure					
	Freshly Cracked		Five Years		Ten Years	
	Bulk Density	Solid Density	Bulk Density	Solid Density	Bulk Density	Solid Density
1	0.56	1.41	0.55	1.24	0.52	1.17
2	0.59	1.38	0.56	1.30	0.53	1.27
3	0.59	1.43	0.59	1.42	0.52	1.25
4	0.61	1.37	0.59	1.30	0.52	1.16
5	0.58	1.38	0.59	1.33	0.54	1.18
6	0.61	1.37	0.57	1.37	0.54	1.29
7	0.58	1.35	0.58	1.32	0.55	1.30
8	0.60	1.35	0.55	1.32	0.54	1.28
9	0.61	1.32	0.59	1.33	0.54	1.28
10	0.59	1.38	0.56	1.37	0.53	1.30
Average	0.60	1.37	0.57	1.33	0.53	1.25

Solid or True Density

As expected, the true density of PKS is found to be higher than the bulk density. The true density decreases from 1.37g/cm^3 for a freshly cracked shell to 1.25g/cm^3 for a cracked shell that has been exposed to inclement weather for ten years. The reduction in the value can also be explained by loss in dry matter content brought about by deterioration of the shell over the years.

Porosity

The estimated porosity is shown in Table 2. The average values of the porosities are 56.6%, 56.6% and 57.4% for fresh PKS, five and ten year post-cracked exposed PKS respectively. The closeness in these average values of porosities may be misleading hence analysis of variance shown in Table 3 was used to compare the porosities of the three samples.

Table 2: Porosity of PKS (%)

	Duration of Post-cracked Exposure		
Replication	Freshly cracked	5 years	10 years
1	60.5	55.1	55.6
2	57.4	56.7	57.7
3	58.7	58.2	57.8
4	55.6	54.6	54.8
5	57.9	55.4	54.7
6	55.4	57.3	58.1
7	54.6	55.8	60.0
8	55.5	58.1	58.0
9	53.6	55.9	58.0
10	57.1	59.2	59.4
Average	56.6	56.6	57.4

From tables of Z and F values, both 0.8958 and 5.994 are significant at the 5% level of significance.

The analysis shows that there is a variation of porosity in the PKS subjected to different periods of exposure after cracking and the porosity increased with the length of exposure. The increase in porosity with increase in exposure periods may not be unconnected with the wearing away of attached fibres on the shell thereby creating an increase in the pore spaces between the shell particles over the years.

Table 3: Summary of the ANOVA for porosity.

Source of variation	Variation or sum of squared deviations	Degree of freedom	Variance
Within columns	9.36	27	0.3467
Between columns	4.16	2	2.08
Total	13.52	29	-
Total variance =	$\frac{13.52}{29}$ =	0.466	

Using Z test at $n_1 = 2$ and $n_2 = 2$, Degrees of freedom.

$$Z = 1.15129 \log \frac{2.08}{0.3467} = 0.8956 \qquad F = \frac{2.08}{0.3467} = 5.994$$

Water Absorption Characteristics

Fig. 1 is a graphical representation of the results. The graph shows that the water absorption capability of a bone dry PKS increases with time up to a period of 30 hours of soaking. The graph shows that saturation moisture content is reached by the samples at about 30 hours of soaking. The difference in saturation moisture content of the samples is an indication that an old PKS can absorb water and attain a higher moisture content at saturation than fresh shell. This implies that the saturated moisture content of soaked PKS increases with an increase in post-cracked exposure period.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are drawn from the experiments carried out.

i. There is a decrease in bulk density of PKS from 0.6g/cm^3 for a freshly cracked shell to 0.53g/cm^3 for a shell that has been exposed to inclement weather for ten years after cracking. For the same shells, the solid density varied from 1.37g/cm^3 for fresh to

1.25g/cm^3 after ten years of post- cracked exposure. These values are within the range of other materials of construction such as Timber which at 18%MC, the bulk density ranges from 0.43 to 1.1g/cm^3 (NCP 2:1973).

ii. The porosity increases with increase in the duration of exposure. This was found to vary from 56.6% to 57.4% over a period of 10 years. This indicates a good potential for use as a material for soil erosion control.

iii. As the post-cracked exposure period increases, there is tendency for it to absorb more water but saturation is attained after 30 hours of immersion in water.

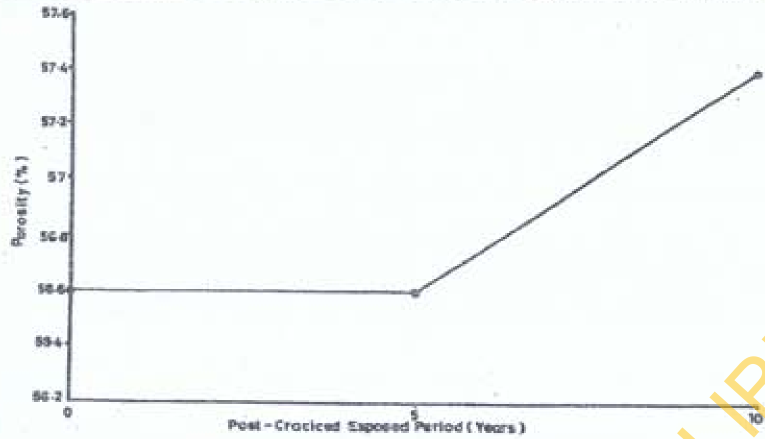

Fig 4: Graph of Porosity of PKS against age

RECOMMENDATIONS

This work has been mainly interested in the effect of age on the densities, porosity, and water absorption characteristics. It is recommended that further tests which should be extended to include the chemical and mechanical properties be undertaken.

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