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Effect of $CacO_3$ and Wood Flour Filler on the Compression Strength of Coconut (Coir) Fibre Reinforced Polymer (FRP) Composite.

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Abstract: Compression test specimens were produced from the composite material of fibre reinforced polymer (FRP). These specimens were tested on the compressive testing machine. The results obtained showed that 5% coconut fibre volume fraction with 95% volume fraction of polypropylene matrix gave compressive strength value of 39.3 Mpa. However, it was observed that when 15% volume fraction of $CaCO_3$ and wood flour filler each were added, the compressive strength increased from 39.3 Mpa to 53.3 Mpa and 39.3Mpa to 43.7Mpa respectively. This observation was discussed in respect of the two fillers.

Introduction

Recently, the re-utilization of agricultural waste, especially of the tropical non-woody fibrous waste, has emerged as an important research area judging from both environmental protection and materials recycling view points [1]. Non-woody agricultural wastes are a great source of raw materials that must be fully exploited. With the appropriate technology these abundant waste materials could be used to replace parts of non-renewable petroleum-based materials, thereby reducing over-dependence on raw materials accruing from exhaustible sources.

One of the non-woody agricultural wastes is coconut (CoCos nucifera) fibres or coirs. It is obtained from the oil palm tree and found to thrive well in tropical rainforests of countries such as Nigeria. To be able to convert the wastes of the coconut fibres into value added new materials is a scientific task. One of the promising alternative methods for achieving this, is by combining the fibres of the coconut wastes with materials of different characteristics such as plastics, to come up with a composite material having improved properties. In this case, the fibres offer a number of advantages as reinforcing fillers in plastic composites, such as high specific strength and/or stiffness, low weight, low cost and lower abrasion to processing equipment [2]. Such synergistic combination of natural fibers, wood, thermoplastics and their composites, synthetic fibers can meet the demanding requirements for construction and transportation industries, namely for motor vehicle components [3]. Automobile bumpers are among the many machine components whose Fibre Reinforced Polymer (FRP) composite fibres may not require expensive pre-moulding processing. Enetanya [4] did comparative work on the prototype of natural organic reinforced polymer with glass reinforced polymer bumper. The results of the work pointed out that both bumpers possess acceptable strengths and other mechanical properties, with estimated total energy absorption capacities per unit weight approximately twenty times that of steel bumpers.

This study presents the coconut fibre (coir) reinforced polymer composite using hand-lay up technique and evaluation of the compression test property of this low cost and value-added new composite material without coupling agents. Also the effects of variation of fillers in proportion by percentage in the composite materials were made known by using compression testing machine.

Experimental

To obtain coconut fibres, the husks were soaked in a 5g/1 aqueous NaOH. Dewaxing by soaking in hot detergent for 1hr. was performed in order to enhance the fibre-matrix surface adhesion. The polypropylene matrix chosen for the work was melted at 175°C in a 60mm diameter aluminum mould enclosed in coils of tungsten wire, insulated in a clay pot which was constructed solely for the work. During the melting process, several proportions measured in volume fraction (V_f) of wood flour and $CaCO_3$ fillers were added to improve the compressive strength of the composite materials.

Wood flour and $CaCO_3$ fillers were added in the following proportions of 5%, 10% and 15% to know their effect on the compressive strength of the composite material. This was based on five percent interval for easy calculation of volume fraction of the fillers. The specimen dimensions were the same i.e. length-40mm, breadth-4mm, and height-20mm. After the specimens were cured for 48hours, they were then tested for compression property. This was done on Hounsfield Monsanto Tensometer material testing machine with a loading capacity of 30KN. This was carried out at room temperature.

Results and Discussion

The compression strength of pure polypropylene is presented in Table 1. The results of the compressive strengths of the coir composite specimens that were produced are shown in Table I

Table I: The results of the compression strength testing in respect of the effect of $CaCO_3$ and wood flour filler.

S/N	Volume fraction fibre (coconut) (%)	Volume Fraction $CaCO_3$ (%)	Volume fraction of wood flour (%)	Volume fraction PP(%)	Compression strength (MPa)
1	5	-	-	95	39.3
2	5	15	-	80	53.3
3	5	-	15	80	43.7
4	10	10	-	80	70.2
5	10	-	10	80	57.2
6	15	5	-	80	87.3
7	15	-	5	80	69.5

Looking at the table the effects, of the two filler additives on the strength of the composite can be compared. The compressive strength of pure polypropylene (PP) was 28.00 Mpa[5]. Thus from Table I it can be adjudged that the filler improved the compressive strength of the composite. The $CaCO_3$ filler has more improvement on the composite compressive strength than woodflour. This improvement of $CaCO_3$ on the composite may be attributed to the chemical structural build-up of the compound as reported by [6].

Also the additional factors responsible for the improvement of the compression strength may be chemical treatment method employed during the fibre extraction phase. The problem of incapable interfacial adhesion of the natural fibres with the polymer matrix was overcome as the fibres were found to possess good wettability with matrix. This may be due to the nature of the microscopic cells of the fibre [7].

From Table I, it can be seen also that the more coconut fibre, the more increment of the compressive strength of the composite. The work still continues to look at the increment of coconut fibre up to 50% volume fraction. The aim here is to verify the law of mixture on the composite.

Conclusion

The conclusion so far is that coconut (coir) fibres possess reinforcing capabilities like any other natural fibres in Fibre Reinforced Polymer (FRP) composite.

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Experimental Method

The area covered presented in 2D-mapping in Fig. 1, was the township section which lies along north-south and east-west borders of the Ashaka Cement industry.

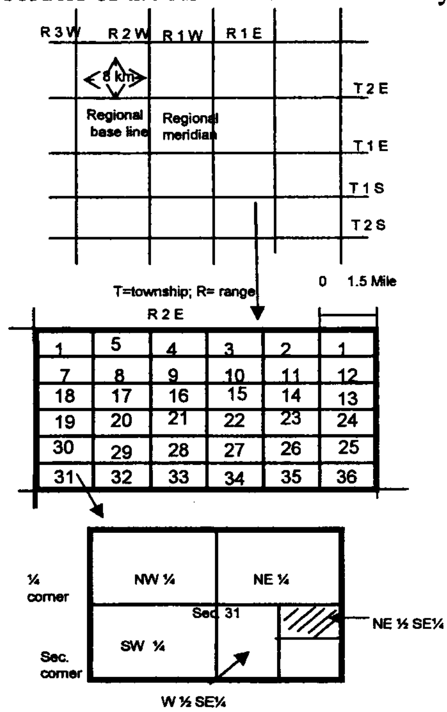

Fig. 1 Localities description of vegetation and ores from Gombe-Bauchi

The orientation study includes observations on the extent, depth and inclination of ore-bodies, the probable grade of the ore and the relation of the ore-bearing bed to the water-table and the plant roots as summarized in Table 1.

Table 1: Transverse description of Sample areas of Ashaka Cement of Gombe- Bauchi.

Sta.1:	is SW corner Elev. = 155.5m Bring total.2; S2W. Vert.< = + 3cm
Sta. 1 to 10m:	Gray mdst with distinctive spheroid frac; no sign dbg; Weather pale tan, and grain of qz, field total 20%; both silt and clay abnt in matrix. A few forams seen but appear forams: leached (sample)
@ Sta. 1 10m.	Ctc ss/mdst, sharp, much glauconitic suggests discont. but beds parallel. Current grooves in mdst trend down-dip
Sta. 3	is 1 X 3cm stake 6m S of n-Bring sta 2 3=S 48W, Dist = 49m.
Sta. 1 + 10m	to sta 3: ss; gray (weather tan), in beds 10cm-1m thick, interbeds carb silty mdst are 10cm-2m in thick, ss mainly med-grained but base of thicker beds course, locally pebby. Minls ss: ang qz (60%), white feld (35), bleached bio(~5)

Note: Sta = Station; ∠ = angle; bdg = bedding; cte = Contact; ss = sandstone; mdst = mudstone; abnt = abundant; carb = carbonaceous; ang = angular; bio = biotite.

The vegetation studied were made of the growth habits of the sesames (Acta), sorghum, soybeans nuts, and dark leafy, species available for sampling. The preliminary samples were collected on both mineralized and unmineralized ground. These were analyzed to determine the amounts of the elements absorbed by the plants in the area under study, using our usual analytical methods [3].

The vegetable (20g of each sample) were dried and extracted with 25% v/v concentrated HNO_3 and H_2O_2. Potassium hydrogen phthalate and sodium tetra-borate were used as standard buffer solutions at 37%. Potassium dichromate (0.2g) was dissolved in distilled water ($60cm^3$). Concentrated hydrochloric acid ($3.5cm^3$) was added to the mixture. The reacting mixture was allowed to stand at room temperature before analysis. All other chemical analysis was carried out using the necessary reagents. The results were analyzed by using statistical method [6].

Results and Discussion

The mean and range results from vegetation and ore from Gombe-Bauchi cement industry are presented in Table 2. The amount of calcium in vegetation in the localities studied shows little variation of between 49.41 and 50.15 $\mu g/ml$. The corresponding concentration of calcium in ore samples range between 58.80 and 60.75 $\mu g/ml$. The relatively high results of calcium in the vegetation necessitated the need to evaluate the action and warning limit for the element in the environment. Consequently the results of calcium from the oxidized zone areas are translated into various mean and bar charts as shown in Figures 2 and 3.

Table 3 represents the precision measurement at normal absorbance (nm) measurement for calcium and other elements for sesamum, sorghum, soybeans and ore samples. This brings the range values close, of between 0.180 to 0.199nm. As a result, spatial variations, though slight were observed. In relative terms comparison of photochemical values obtained in this study can be inferred to be high compared with the W.H.O. standard of 0.05 and 0.03nm for magnesium and lead respectively [7-9].

Table 2: The mean and range results for calcium from vegetation and ore- bodied samples of Gombe-Bauchi cement industry environments.

Sample	VGB		OBS	
	***Mean**	***Range***	***Mean**	***Range***
1	50.11	0.1	60.11	0.21
2	50.13	0.2	59.96	0.31
3	49.49	0.15	60.06	0.28
4	49.96	0.1	59.81	0.15
5	49.94	0.1	59.81	0.10
6	50.01	0.3	60.39	0.21
7	49.98	0.25	60.71	0.15
8	50.00	0.25	60.10	0.20
9	50.00	0.25	60.10	0.20
10	50.08	0.7	60.15	0.45

Table 3: Precision measurement at normal absorbance levels for calcium and other elements from vegetation and ore-bodied samples.

Measure ments	*Mean Absorbance*				*S. D*			
	Ca	*Pb*	*Mg*	*Zn*	*Ca*	*Pb*	*Mg*	*Zn*
VGB (Sesamum (Acta) sorghum soyabeans)	0.180	0.07	0.11	0.04	0.30	0.2	0.1	0.1
	0.183	0.05	0.13	0.06	0.50	0.11	0.3	0.4
	0.185	0.05	0.11	0.05	0.80	0.32	0.4	0.51
OBS	0.191	0.07	0.15	0.08	1.00	0.33	0.2	0.11
	0.192	0.08	0.14	0.07	1.20	0.35	0.05	0.50
	0.199	0.07	0.14	0.07	1.31	0.53	0.15	0.34

VGB = vegetation; OBS = ore-bodied Areas; *mean of four different locations.

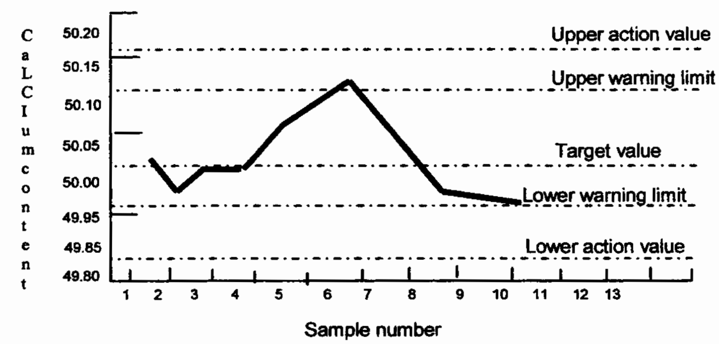

Fig. 2: Mean (x) chart for vegetation in cement industry e

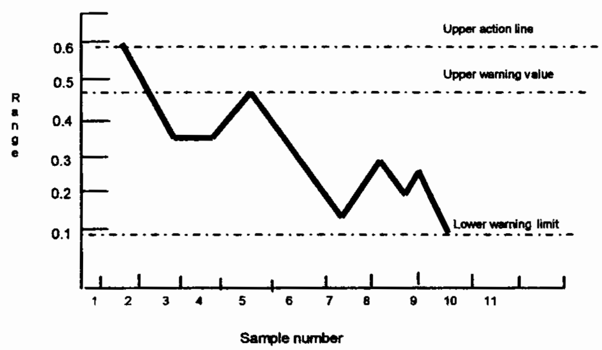

Fig. 3: The range chart for vegetables samples from Gombe-Bauchi.

In Fig. 2, the mean values of calcium in cement industry environs show different peaks. This suggests a difference in the action value and warning limits in different localities presented in description of sample location of vegetation and ores from Gombe-Bauchi in Fig 1.

Similarly in Fig. 3 the range of the calcium in vegetation sample in each localities exhibit different warning and action values. Since the calcium content of up to 52.2 $\mu g/ml$ is close to the value as high as 60.80 $\mu g/ml$ (see tables 2 and 3), in the ore, this difference would be attributed to the cloistering effect of the 2D-mapping coverage of the localities. The figure shows an increase in calcium content in localities 3 to 6. The effect is that action values continue to go up for vegetation in cement industry environment. The lower action line is due to locality being far away from the cement industry environ.

The standard errors, which also refers to the standard deviation as action line were identified as action value at $\bar{X}\pm 3\delta/\sqrt{n}$, which is equivalent to 59.16 and 49.84 $\mu g/ml$, while two standard error as warning lines, that is, $\bar{X}\pm 2\delta/\sqrt{n}$ resulting in 58.91 $\mu g/ml$.

Considering the relatively high level of calcium in vegetable in the cement environs, there can be likelihood of toxic reaction from the environment which can be detrimental to vegetable and human [7, 8]. As a result of the high level of calcium, and relatively high amounts of other elements such as lead, zinc and magnesium, it is worth pointing out that the secondary calcareous carbonate minerals such as hydrocerussite, $Zn_5(CO_3)_2(OH)_6$, hydrocerussite, $Pb_3(CO_3)_2(OH)_2$, plumbonacrite, $PbOO(OH)_6$, Dypingite, $Mg_5(CO_3)_4.(OH)_2.5H_2O$ might be expected at Gombe-Bauchi environment. This depends on the ratio of a $(Ca^{2+})/a(Mg^{2+})$, $a(Ca^{2+})/a(Zn^{2+})$ and $a(Ca^{2+})/a(Pb^{2+})$ most of which are base-metal elements. These associate and very rare minerals may found various uses in technology and pharmaceutical industries.

It should be noted that green leaves of plant contain chlorophylls which are the Mg-porphine (base-metal containing) complexes primarily involved in photosynthesis. Preeminent in importance among the macro cyclic complexes of Group 11A elements are the chlorophylls complexes of Mg. These are compounds vital to the process of photosynthesis in green plants. Magnesium and calcium are also intimately in biochemical processes. Photosynthesis is essentially the conversion of radiant electromagnetic energy (light) into chemical energy in the form of adenosine triphosphate (ATP) and reduced nicotiamide adenine dineotide phosphate (NADP). This energy eventually permits the fixation of CO_2 into carbohydrates, with the liberation of O_2. As such, the process also provides materials for fuel (wood, coal, petroleum) fibre and innumerable useful chemical compound in the cement environ.

Conclusion

The on-going observations and discussion on carbonate containing secondary minerals especially those of the common base metals suggested that magnesium, lead and zinc containing secondary ores may be found in Gombe-Bauchi ore-bodied in association with other minerals which can found various uses in chemical, medical and bio-technology etc.

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