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COMPRESSIVE AND FLEXURAL STRENGTH OF CEMENT MORTAR STABILIZED WITH RAFFIA PALM FRUIT PEEL (RPEP)

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ABSTRACT

Mortar is a material with wide range of applications in the construction industry. However, plain mortar matrices are usually brittle and often cracks and fails more suddenly than reinforced mortars. In this study, the compressive and flexural strengths of cement mortar stabilized with Raffia Palm Fruit Peel (RPFP) as fibre were determined. The cement-sand mortars were in the ratios of 1:1 and 1:2 respectively. They were stabilized with 2%, 4%, 6% and 8% RPFP fibres respectively by volume using a water cement ratio of 0.5. Test cubes and beams measuring 150 x 150 x 150mm and 160 x 40 x 40mm were cast and subjected to cube and central point loading crushing tests respectively. Density measurements were also taken. The compressive strength of test specimens were found to reduce with increases in RPFP fibre while the flexural strength increased with increase in the fibre content. The average compressive strength after 28 days of curing was 10.67N/mm^2 at 8% stabilization for the 1:1 mix and 10.01N/mm^2 at the same percentage stabilization for 1:2 mix ratio. Also the average flexural strengths (i.e. Modulus of Rupture) were 4.26N/mm^2 and 4.29N/mm^2 respectively for the two mix ratios at the same fibre percent and curing period. The densities decreased with increase of fibre content. The results compare well with similar tests on mortars stabilized with coir, rice husk and sawdust. The results confirm that fibre stabilized mortars could be used as light-load bearing members in civil engineering constructions.

KEYWORDS: Mortar, Raffia Palm Fruit Peel (RPFP), Fibre, Modulus of Rupture, Compressive Strength.

INTRODUCTION

Mortar is one of the most widely used structural materials, as it can offer good performance for bedding unit masonry, plastering and with the addition of coarse aggregates for concrete. However, plain mortar materials are usually brittle and often crack more easily and fail more suddenly than reinforced or stabilized mortars. In the same vein, cement-based matrices are becoming more expensive because of the rising cost of cement, which has also affected the conventional roofing sheets and tiles.

The introduction of fibres as stabilizers to cement mortars is expected to ameliorate these problems. This is because fibres are light, cheap, affordable and possess properties that place them at advantage over plain mortar when combined with mortar at optimum percentage or volume ratio, these include higher tensile and impact strength, higher elastic modulus, better sound proofness and lower thermal conductivity (Ndububa, 2000).

The properties of some natural fibres have been studied by several investigators including Mattone (1990). Some of those found to be of use as stabilizing material includes the fibres from elephant grass, sisal, coconut-coir, sugarcane baggase, saw dust and asbestos. Dahunsi (2000) reported that cement matrices

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reinforced with natural materials have been adapted to various uses such as construction of reservoirs, pipes, floors and covers. The Raffia Palm Fruit Peel (RPFP) is the outer layer of hard, glossy, imbricate reddish – brown scales covering the large avoid fruits of the raffia palm tree (Raphis Famifera). The fruits are as big as hen's egg with a single hard nut. The rhomboid triangular and apex – beaked peels are arranged in overlapping vertical rows on the fruits each with a median grove. The RPFP reported in this paper were sourced from Benue State of Nigeria. The local people tap raffia palm wine from the tree stem and use the leaves for roofing and fencing.

According to Cabrera and Nwaubani (1990), fibres assist in arresting plastic and initial drying shrinkages cracks and limit the propagation of micro cracks when concrete is subjected to tensile loading.

This study investigated the compressive and flexural properties of RPFP and evaluated its potential as a stabilizing material to improve the performance of mortar in both wet and hardened states.

2.0 MATERIALS AND METHODS

2.1 Preparation of Materials

The fruits were air-dried for 96 hours and later cooked in a large metal pot for 2 hours. The cooking softened the fruits and facilitated easy removal of the hard scaly outer peel layer used as the RPFP fibre.

Un-compacted bulk density of the RPFP was determined by filling up a cylinder of known weight and volume with it. The weight of container and sample was recorded and bulk density calculated as the weight of RPFP per volume of the cylinder. The moisture content of RPFP samples was evaluated by measuring the weights of fibre samples in its wet and oven dry states respectively. The moisture content was calculated as the ratio of the amount of water present in samples to its oven – dried weight.

2.2 Mixing, Casting and Compaction

Batching of sand and cement was by volume in the ratios of 1:1 and 1:2. The cement was first mixed thoroughly dry with sand before fibre was introduced to the dry mixes in the percent quantities of 2%, 4%, 6% and 8% by volume of the dry matrix respectively of the matrices. These were thoroughly mixed again before water was introduced. A water/cement ratio of 0.5 was maintained. The mixing continued until a workable mix was achieved.

The formworks for the test cubes and beams were adequately lubricated before casting. In accordance with ASTM specification, the wet samples were placed in three layers each and compacted in three rounds of four strokes each. Five samples were prepared for the respective mortars for testing (minimum of three is allowed by ASTM). Toweling was done to smoothen the surface and remove excess materials.

2.3 Curing

The specimens were cured by wet sac and water sprinkling under laboratory conditions. The atmospheric temperature ranged between 20 and 32^0C. Curing was done for 28 days before testing was carried out.

2.4 Testing

Test beams and cubes measuring 160 x 40 x 40mm and 150 x 150 x 150mm respectively and having 1:1 and 1:2 mix proportions were tested. The flexural strength of the beams at 28 days were determined using central point loading in accordance with the requirements of BS 1881: part 118 (1983). Similarly test cubes were crushed to evaluate the compressive strength of test samples as prescribed by BS 1881: part 119 (1983).

3.0 RESULTS AND DISCUSSIONS

The moisture content of air – dried RPFP samples were found to range between 6% and 16%. The average moisture content was 12.8%. The moisture content of the fibre may have an effect on the strength properties of mortar as some of the water needed for the production of a workable mortar mix may be absorbed by unsaturated RPFP.

The compressive strength of RPFP stabilized mortar was found to reduce with further increment in the percentage of stabilization as shown in Table 1 and 2, and figure 1 and 2. This could be attributed to the increase in void spaces with increasing volume of RPFP in the mortar. Modulus of Rupture is a measure of the Flexural Strength. It was observed to have increased with increase in RPFP fibre content as presented in Table 3 and 4, and Figure 3 and 4 respectively. The results also show that plain mortar possessed higher strengths, however the failure modes for the plain samples were sharp and sudden, and exhibiting considerable brittleness. It is observed that the 1:1 and 1:2 mortars as stabilized with RPFP fibres did not show any significant differences in both compressive and flexural strength results, thereby conferring an economic advantage to the 1:2 mix over the 1:1 mix. From Table 3 and 4 the densities decreased with increase of fibre content. At 8% for the 1:1 mix and, 6% and 8% for the 1:2 matrix the densities recorded lower values below 1800Kg/mm^3 thereby passing for light-weight structural materials at this levels.

An earlier report by Ndububa (2000) on mortars stabilized with vegetable fibres confirmed their suitability as alternative materials in light-weight constructions particularly in roofing sheets, tiles and partition walls. In comparative terms, mortar stabilized with RPFP fibre possesses higher compressive and flexural strengths over those stabilized with coir, rice husk and sawdust as given in the same report. This might be due to the higher compressive and tensile strength of RPFP fibres over the others.

Table 1: Compressive Strength of 28-day 1:1 mix Mortar Stabilized with RPFP

Beam Ref. No.	**% of RPFP**	**Crushing load (KN)**	**Compressive strength (N/mm^2)**	**Average compressive strength (N/mm^2)**
A1	0	575	25.56	25.28
A2		480	21.33	
A3		565	25.11	
A4		655	29.11	
B1	2	300	13.33	12.28
B2		285	12.67	
B3		290	12.89	
B4		230	10.22	
C1	4	325	14.44	12.06
C2		265	11.78	
C3		235	10.44	
C4		260	11.56	
D1	6	265	11.78	11.78
D2		240	10.67	
D3		315	14.00	
D4		245	10.89	
E1	8	255	11.33	10.67
E2		160	7.11	
E3		295	13.11	
E4		250	11.11	

Table 2: Compressive Strength of 28 – day 1:2 mix Mortar Stabilized with RPFP

Beam Ref. No.	**% of RPFP**	**Crushing load (KN)**	**Compressive strength (N/mm^2)**	**Average compressive strength (N/mm^2)**
F1	0	517.5	23.01	23.23
F2		501	22.71	
F3		538	23.90	
F4		524	23.30	
G1	2	360	16.00	14.5
G2		300	13.33	
G3		335	14.89	
G4		310	13.78	
H1	4	310.5	13.8	11.69
H2		270.5	12.02	
H3		250.5	11.13	
H4		220.5	9.8	
J1	6	230	10.22	11.33
J2		235	10.44	
J3		325	14.44	
J4		230	10.22	
K1	8	205	9.11	10.01
K2		215	9.56	
K3		246	10.93	
K4		235	10.44	

Table 3: Flexural Strength of 28 – day 1:1 mix Mortar Stabilized with RPFP

Beam Ref. No.	**% of RPFP**	**Overweight of sample (Kg)**	**Load at failure (N)**	**Density of sample (Kg/mm^3)**	**Modulus of Rupture (N/mm^2)**	**Ave. Modulus of Rupture (N/mm^2)**
A1	0	0.547	2060	2137	5.55	5.6
A2			2205		5.51	
A3			2380		5.95	
A4			2175		5.44	
A5			2375		5.94	
B1	2	0.502	1575	1960	3.94	2.85
B2			1250		3.13	
B3			1425		3.56	
B4			1450		3.63	
B5						
C1	4	0.486	1140	1896	2.85	3.96
C2			1450		3.63	
C3			1820		4.55	
C4			1800		4.50	
C5			1600		4.00	
D1	6	0.471	1760	1840	4.40	4.08
D2			1760		4.40	
D3			1640		4.10	
D4			1635		4.09	
D5			1635		3.39	
E1	8	0.455	1530	1777	3.83	4.26
E2			2070		5.18	
E3			1335		3.34	
E4			1875		4.69	
E5			1700		4.25	

Table 4: Flexural Strength of 28 – day 1:2 mix Mortar Stabilized with RPFP

Beam Ref. No.	**% of RPFP**	**Overweight of sample (Kg)**	**Load at failure (N)**	**Density of sample (Kg/mm^3)**	**Modulus of Rupture (N/mm^2)**	**Ave. Modulus of Rupture (N/mm^2)**
F1 F2 F3 F4	0	0.516	1625 1905 1725 1850	2015	4.06 4.76 4.31 4.63	4.44
G1 G2 G3 G4 G5	2	0.490	1225 1300 860 1500 1345	1914	3.06 3.25 2.15 3.75 3.36	3.11
H1 H2 H3 H4 H5	4	0.470	1530 1370 1260 1275 1475	1836	3.83 3.43 3.15 3.19 3.69	3.46
J1 J2 J3 J4 J5	6	0.459	1770 1750 1780 1510 1800	1793	4.43 4.38 3.95 3.78 4.50	4.20
K1 K2 K3 K4 K5	8	0.442	1680 1960 1570 1550 1720	1727	4.20 4.90 4.20 3.93 4.22	4.29

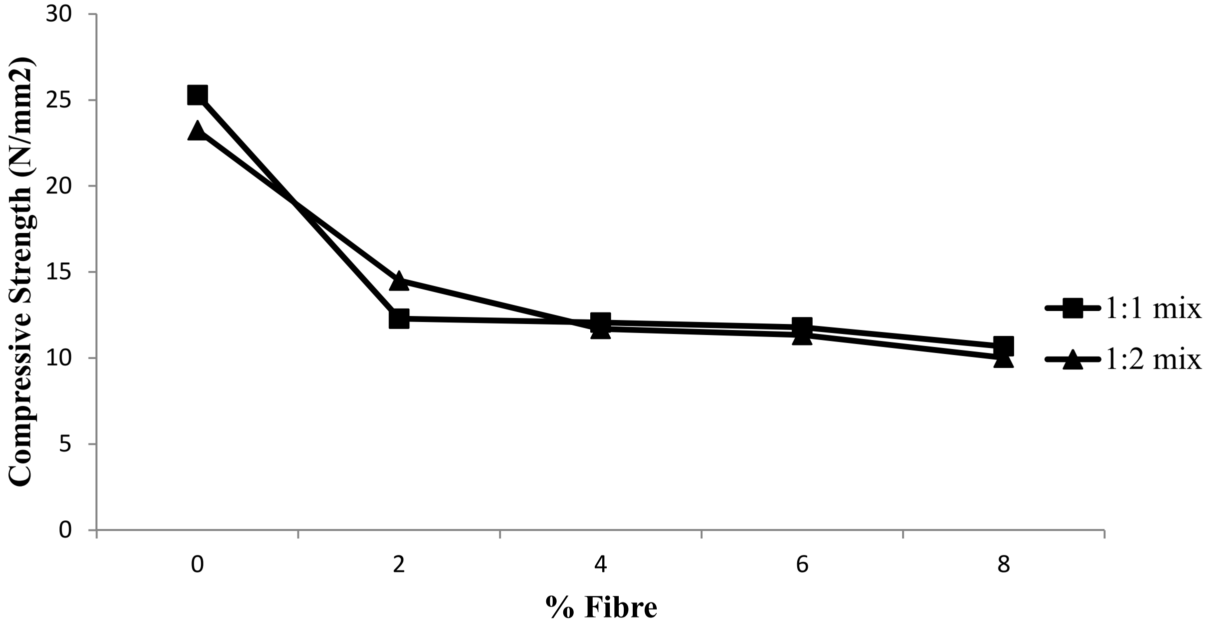

Fig. 1: Compressive Strength of Mortar stabilized with RPFP Fibre

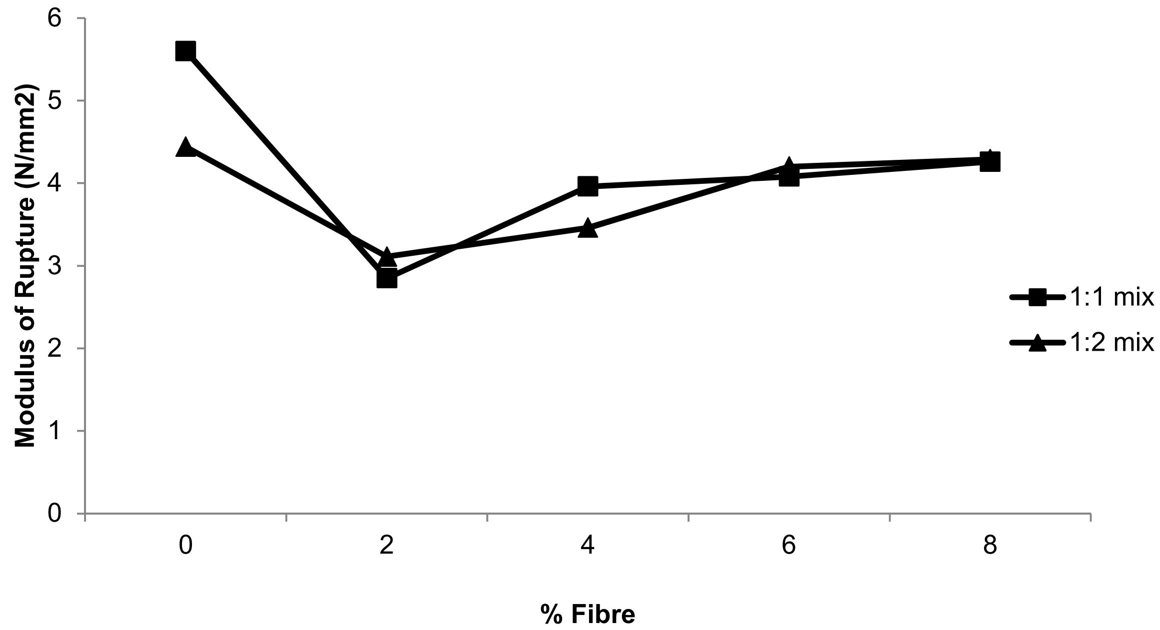

Fig. 2: Flexural Strength of Mortar Stabilized with RPFP Fibre

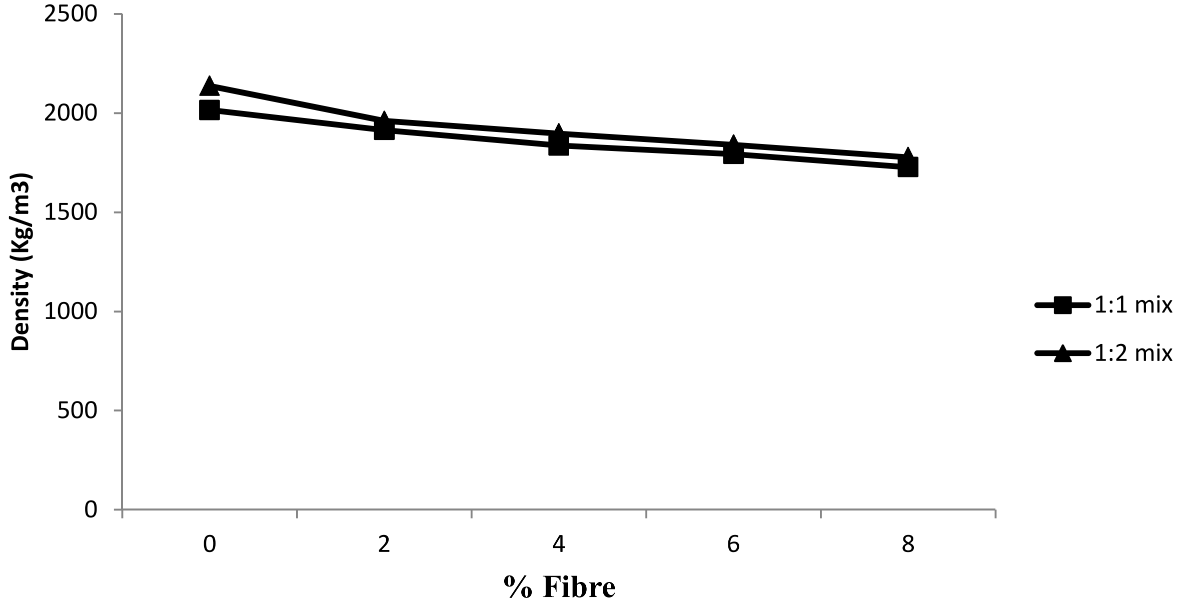

Fig. 3: Density of Mortar Stabilized with RPFP Fibre

CONCLUSION

From this study, the effects of raffia palm fruit peel as a mortar stabilizing agent have been presented. It could be concluded that reinforcing mortar beams with raffia palm fruit peel fibres improved the flexural strength but resulted in reduction of compressive strength at percentage composition of RPFP of 4% and above. The flexural and compressive strengths of RPFP stabilized mortar were adequate enough for the construction of light-weight structural elements.

The most important applications of fibre mortar could be in the production of roofing sheets, ceiling sheets, tiles and partition walls.

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