EFFECTS OF PARTICLE SIZE, COMPOSITE MIX AND COLD WATER TREATMENT ON THE COMPRESSIVE STRENGTH OF *EREMOSPATHA MACROCARPA*–CEMENT COMPOSITE

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ADEFISAN OO, IDRIS A & OJEABULU J. 2012. Effects of particle size, composite mix and cold water treatment on the compressive strength of *Eremospatha macrocarpa*–cement composite. Rattan–cement composites were manufactured using different particle sizes (0.60, 0.85 and 1.18 mm) of untreated *Eremospatha macrocarpa* cane and those treated in cold water using cement–sand ratio of 1:3 and 10% of rattan based on the cement mass. Specimens were tested for compressive strength after 28 days of curing. Increasing the particle size and inclusion of sand in the composite mix reduced the compressive strength while pre-treatment with cold water enhanced the compressive strength. The compressive strength of *E. marcocarpa*–cement composites was influenced by the interactions of pre-treatment and particle size as well as pre-treatment, particle size and composite mix.

Keywords: Rattan canes, aqueous pre-treatment, particle geometry, composite strength

ADEFISAN OO, IDRIS A & OJEABULU J. 2012. Kesan saiz partikel, campuran komposit dan rawatan air sejuk terhadap kekuatan mampatan komposit *Eremospatha macrocarpa*–simen. Komposit rotan–simen dihasilkan menggunakan partikel rotan pelbagai saiz (0.60 mm, 0.85 mm dan 1.18 mm), nisbah simen–pasir sebanyak 3:1 dan 10% rotan berdasarkan berat simen. Partikel diperoleh daripada rotan *Eremospatha macrocarpa* yang tidak dirawat dan yang dirawat dengan air sejuk. Spesimen diuji kekuatan mampatannya selepas 28 hari pengesetan. Kekuatan mampatan berkurangan apabila saiz partikel bertambah besar dan apabila pasir hadir dalam komposit campuran. Prarawatan dengan air sejuk meningkatkan kekuatan mampatan komposit. Kekuatan mampatan komposit *E. macrocarpa*–simen dipengaruhi oleh interaksi antara prarawatan dengan saiz partikel dan antara prarawatan dengan saiz partikel dengan campuran komposit.

INTRODUCTION

The use of wood or lignocellulosic particles in cementitious composites dates back to ancient times. They are incorporated as reinforcement to enhance crack resistance, ductility, energy absorption and also to ensure stress reduction and impart a well-defined post-cracking and post-yield behaviour (Swamy 1990, Olorunnisola 2007). Therefore, construction industries around the world are now utilising cementitious composites or cement-bonded composites (CBCs) for housing due to admirable properties such as environmental friendliness, resistance to fire, insects and fungi, good structural performance and ease of manufacture (Goodell et al. 1997, Fabiyi 2003, Pereira et al. 2006, Olorunnisola 2007).

Numerous lignocellulosic materials have been tested and found suitable for use as furnish in manufacturing CBCs. These range from different species of wood and agricultural to building construction wastes (Badejo 1998, Remirez-Corretti et al. 1998, Wolfe & Gjinolli 1999). Particles extracted from these lignocellulosics often contain inhibitory substances such as hemicelluloses, simple sugars and tannins which hinder cement setting and formation of strong crystalline bonds. Therefore, aqueous pre-treatment with cold water is sometimes employed to minimise the retarding effects of water-soluble components of these substances on cement hardening (Olorunnisola 2008).

In Nigeria, rattan canes are now being considered as a candidate furnish for CBC production due to their availability and accessibility. Different rattan such as *Calamus deerratus* and *Laccosperma secundiflorum* have been tested and found suitable for CBC production (Olorunnisola et al. 2005a, b, Adefisan &

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Olorunnisola 2007, Olorunnisola 2008). However, there is a dearth of information on the potential of *Eremospatha macrocarpa* canes for CBC manufacture. The knowledge of properties of cement composites made from *E. macrocarpa* canes will help in alleviating the over-exploitation of the dwindling timber resource in Nigeria. They can serve as potential low-cost construction material, thus cushioning the rising cost of building components. This paper examines the effects of composite mix and cold water treatment on the compressive strength of cement composites made from *E. macrocarpa* canes.

MATERIALS AND METHODS

Samples of *E. marcocarpa* canes were harvested from Kajola Oniparaga Forest Reserve in Odigbo Local Government Area, Ondo State, Nigeria. The canes were identified by comparing with specimens kept in the herbarium of the Department of Botany and Microbiology, University of Ibadan. The canes were converted into billets of about 6 cm and hammer milled. The milled particles were collected and sieved using a set of 2.34, 1.18, 0.85 and 0.60 mm sieves, air dried to 10% moisture content and separated into two portions, i.e. untreated and subjected to cold water pre-treatment. Pre-treatment involved soaking the particles in deionised cold water (25 °C) for 30 min, draining and rewashing with deionised water to remove soluble extractives, and air drying for 14 days to an average moisture content of 10%.

Test samples were produced in three replicates using moulds of size 100 mm × 100 mm × 100 mm at the following levels: cement–sand ratio 1:3, 10% rattan content as well as 0.60, 0.85 and 1.18 mm particle sizes. Treated and untreated rattan particles were dry mixed manually in a container with cement. Deionised water was added at a rate of 0.25 mL g^{-1} of cement + 7.50 mL g^{-1} of rattan particles (Olorunnisola et al. 2005b). The composites were demoulded after about 24 hours, cured under a wet cloth at room temperature (23 ± 2 °C) for a period of seven days, and then kept at 23 ± 2 °C and relative humidity of 65 ± 5% for another 21 days. Specimens were loaded perpendicular to the direction of casting on a 100 kN Universal testing machine and tested at cross-head speed of 1 mm min^{-1}.

RESULTS AND DISCUSSION

Compressive strength

The compressive strength of the rattan–cement composites ranged from 14.8 to 22.7 N mm^{-2} without pre-treatment and from 18.3 to 21.7 N mm^{-2} when treated with cold water (Table 1). These values compared favourably with those reported by Olorunnisola et al. (2005a) and Olorunnisola (2007) and were higher than the value 1.4 N mm^{-2} recommended by Opoko (2004) for bricks for use in bungalows and single storey houses in Nigeria.

Effect of particle geometry on compressive strength

Composites bonded with 0.60 mm particle size generally had higher compressive strength than those bonded with either 0.85 or 1.18 mm (Table 1). This suggested that there was poor interfacial adhesion between large rattan furnish and cement, resulting in low compressive strength (Olorunnisola et al. 2005b). Smaller lignocellulosic particles bonded better with cement than larger particles, thereby, reducing the presence of air voids (Karade 2003, Olorunnisola 2007). One of the major strength-reducing characteristics in cement-based materials is air void (Olorunnisola 2007). Increase in particle size from 0.60 to 1.18 mm may have increased air voids in the rattan–cement mixes which consequently may have reduced the compressive strength of the *E. marcocarpa* composites. Statistical analysis showed that the particle size had significant effect ($p < 0.05$) on the compressive strength of *E. marcocarpa* mixes (Tables 2 and 3).

Effect of cold water treatment on compressive strength

The compressive strength of cold water-treated *E. marcocarpa* composites ranged between 18.3 and 21.7 N mm^{-2} (Table 1). Pre-treating rattan particles with cold water significantly increased the compressive strength of *E. marcocarpa* composites (Table 3). This suggested that cold water treatment removed offending substances that might impair bonding between rattan particles and cement (Olorunnisola 2008), enhanced formation of strong crystalline bond and consequently improved the compressive strength of rattan–cement mixes.

Table 1 Compressive strength of *Eremospatha marcocarpa*–cement composite

Particle size (mm)	Pre-treatment	Composite mix	Compressive strength (N mm^{-2})
0.60	None	Rattan + cement	22.7
0.85	None	Rattan + cement	19.8
1.18	None	Rattan + cement	14.8
0.60	Cold water	Rattan + cement	20.9
0.85	Cold water	Rattan + cement	21.7
1.18	Cold water	Rattan + cement	18.3
0.60	None	Rattan + cement + sand	7.3
0.85	None	Rattan + cement + sand	8.6
1.18	None	Rattan + cement + sand	6.0
0.60	Cold water	Rattan + cement + sand	12.5
0.85	Cold water	Rattan + cement + sand	5.6
1.18	Cold water	Rattan + cement + sand	7.7

Table 2 Analysis of variance of the effects of pre-treatment, particle size and composite mix on compressive strength of *Eremospatha marcocarpa* composite

Source	Df	Mean square value of compressive strength
Pre-treatment (T)	1	14.063*
Particle size (P)	2	51.55*
Composite mix (M)	1	1242.56*
P × M	2	24.13*
T × M	1	0.0069
T × P	2	7.88*
T × P × M	2	28.63*
Error	24	1.786

* Significant at 0.05 level of probability

Effect of composite mix on compressive strength

The inclusion of sand in *E. marcocarpa*–cement mixes resulted in between 57 and 68% reduction in compressive strength (Table 1). Higher volumes of voids (porosity) and poor interfacial bonding might have occurred due to the addition of sand in the rattan composites. This resulted in loss of compressive strength. This observation conformed with that of Olorunnisola (2007), suggesting that increased porosity in cement-based materials had negative effects on strength properties. Statistical analysis (Table 3) revealed that inclusion of sand significantly reduced the compressive strength of the *E. marcocarpa*–cement composites. Addition of chemical accelerators such as calcium chloride may aid strong bond formation and enhance the compressive strength of composites.

Apart from the interaction of pre-treatment and composite mix, the interactions of pre-treatment and particle size as well as pre-treatment, particle size and composite mix had significant effects on the compressive strength of *E. marcocarpa*–cement mixes (Table 2). This implied that the combined effects of cold water pre-treatment and inclusion of sand in the composite mixes did not enhance the compressive strength of *E. marcocarpa*–cement composites.

Table 3 Multiple comparison of the effects of pre-treatment, particle size and composite mix on the compressive strength of *Eremospatha marcocarpa* composite

Factor	Compressive strength (N mm^{-2})
Pre-treatment	
None	13.2 b
Cold water	14.5 a
Particle size	
0.60 mm	15.9 a
0.85 mm	13.9 b
1.18 mm	11.7 c
Composite mix	
Rattan + cement	19.7 a
Rattan + cement + sand	8.0 b

Means with the same letters are not significantly different

CONCLUSIONS

Particles of *E. macrocarpa* canes could be used as reinforcement in CBCs. Increase in particle size and inclusion of sand in the composite mix reduced the compressive strength of composites. Pre-treating particles of *E. marcocarpa* canes with cold water enhanced the compressive strength of cement mixes.

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