Effect of Moisture on Natural Fibre Reinforced Plastics.

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Abstract

In this research, the rate of moisture absorption of the composites reinforced with natural fibres – Ukam plant fibres (chochlostermum placoni) were studied and determined.Composite cubes and plates of different sizes were prepared, then immersed in water for 24 hours at room temperature in order to determine the extent of moisture absorbtion. This was found to be relatively lower for longitudinal arrangement of fibres compared to transverse arrangement. It was observed that the Longitudinal and transverse moisture expansion coefficients were 0.496 and 0.644 respectively.

Keywords: Composites, Natural Fibre, Matrix, Absorption, Moisture Expansion Coefficients.

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1.0 introduction

Composite materials are defined as a mixture of two or more relatively homogeneous materials which have been bonded together to produce a material with properties that are superior to the ones exhibited by the individual component materials[1]. In practice, most composites consist of two or more discrete physical phases, in which a fibrous phase is dispersed within a continuous matrix phase, and the fibrous phase must retain its physical identity, such that it conceivably can be removed from the matrix intact [2]. In the world of technology today, attention is on Natural fibres as reinforcement for resin matrices.

For centuries, mankind has used natural fibres for various types of applications including building materials, making of ropes, spacecraft applications, and the automobile industries have also come up as some of their main beneficiaries [3]. In most countries, users have explored the possibilities of using natural fibres from different plants, which include bagasse, cereal straw, corn stalk, cotton stalk, banana fibres, rice husk / rice straw [4]. The renewed interest resulted in new ways of natural fibre modifications and use and brought them to be superior to synthetic fibres. Composites (reinforced with natural fibres) – the wonder material, with light-weight, high strength to weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, woods and non-renewable (synthetic) fibres which are more expensive [5]. The natural and wood fibres derived from annually renewable resources, as reinforcing fibres, in both thermoplastic and thermoset matrix composites provide positive environmental benefits with respect to ultimate disposability and raw material utilization [6].

2.0 Materials And Methods

The materials used in this work include:

i. Ukam plant fibres (chochlostermum placoni)
ii. Polyester resin.
iii. Catalyst (methyl ethyl ketone)
iv. Accelerator (cobalt)
v. Gell coat

Specimens were prepared and grouped into specimens “P” and “Q”. Specimen ‘P’ comprises of composite cubes of different sizes (i.e. A, B & C) and different V_f. Specimen ‘Q’ comprises of composite plates of different sizes and different V_f. (I.e. D & E) the weights of the specimens were taken dry, they were then immersed in water for 24 hours at room temperature. After 24 hours, the specimens were brought out, dried with towel and weighed again. The summary of these processes are tabulated below

2.1 Observations

Table 1 Moisture Intake of the composite of Ukam Plant Fibres

Specimen	Mass of dry specimen (g)	Mass of moist specimen in (g)	Mass of water absorbed (g)	Percent moisture content "C" (%)	Volume of specimen (Cm^3)
SPECIMEN 'P'- COMPOSITE CUBES (20x20x20) mm^3					
A (control)	13.55	13.57	0.02	0.148	9.261
B – 10% V_f	10.16	10.20	0.04	0.394	7.600
C – 30% V_f	12.38	12.46	0.08	0.646	8.379
Specimen 'Q'- Composite Plates					
D – 30% V_f	15.05	15.17	0.12	0.797	11.040
E – 10% V_f	10.12	10.16	0.04	0.395	5.75

2.2 Densities of polyester resin and ukam plant fibres

$$C = \frac{m}{v} \qquad - \quad - \quad - \quad - \quad - \quad - \quad - \qquad (1)$$

Where m = mass, v = volume and ρ = density.

Table 2 properties of Ukam plant fibres and polyester resin.

Property	Polyester Resin	Ukam Plant Fibres
Mass (kg)	0.747	0.036
Volume (m^3)	5.98×10^{-4}	2.73×10^{-5}
Density (kg/m^3)	1.25×10^{3}	1.32×10^{3}

2.3 Moisture expansion coefficients

Moisture absorption by a body (e.g., resin matrix) in composite materials causes a volumetric change in the body. Because of this, coefficient of moisture expansion becomes a composite property that should be studied andDetermined [7].

The percent moisture content, C, in a body is defined as

$$C = \frac{\textbf{Weight of moist material} - \textbf{Weight of dry material}}{Weight of dry material} \times 100 \quad (2)$$

A coefficient of moisture expansion, **β**, can be defined as the change in linear dimension of the body per unit initial length per unit change in moisture concentration, and moisture concentration may be defined as the weight of moisture present per unit weight of the body [8].

By converting the weight of moisture content to its volume and considering that linear strain is only one third of the volumetric strain, the expression for **β** of a body can be expressed thus:

$$\beta = \frac{1}{3}\frac{\rho}{\rho_w} \quad (3)$$

Where ρ = density of the body

ρ_w = density of water.

Equation (3) is applicable when there are no voids in the body. When voids are present, the actual expansion of the body due to moisture will be less than that indicated by equation (3)

Moisture absorbed by the matrix results in a volume change of the composite. However, the expansion of unidirectional composites in the longitudinal direction is negligible because of the much higher stiffness of the fibres. Therefore, the longitudinal coefficient of moisture expansion, β_L of a unidirectional composite is taken to be zero. The transverse coefficient of moisture expansion, β_T, of the unidirectional composite, is related to the moisture expansion coefficient of the matrix, β_m, as follows:

$$\beta_T = \frac{\rho_c}{\rho_m}(1 + \nu_m)\beta_m \quad (4)$$

Where ρ_c = density of the composite.

ρ_m = density of matrix materia

ν_m = Poisson's ratio of the matrix.

Using equation (3) and the data obtained from the experiment performed, the moisture expansion coefficient of the matrix, composite and Ukam plant fibres are calculated thus:

Given that:

$\rho_c = 1.34 \times 10^3\ kg/m^3$ (for 10% V_f)

$\rho_m = 1.25 \times 10^3\ kg/m^3$

$\rho_f = 1.32 \times 10^3\ kg/m^3$

From Eq. (3),

$$\beta_{c\ 10\%\ V_f} = \frac{1}{3}\left\{\frac{1.340}{1.000}\right\} = 0.447$$

$$\beta_{c\ 30\%\ V_f} = \frac{1}{3}\left\{\frac{1.487}{1.000}\right\} = 0.496$$

$$\beta_m = \frac{1}{3}\left\{\frac{1.249}{1.000}\right\} = 0.416$$

$$\beta_m = \frac{1}{3}\left\{\frac{1.320}{1.000}\right\} = 0.44$$

Similarly, given that

$\rho_c = 1.34 \times 10^3\ kg/m^3$

$\rho_m = 1.25 \times 10^3\ kg/m^3$

$\beta_m = 0.416 \times 10^3\ kg/m^3$

$\nu_m = 0.3$

And recalling Equation (4), the transverse coefficient of moisture expansion (β_T) is calculated thus:

$$\beta_T = \frac{1.340}{1.249}(1 + 0.3)0.416$$

= 0.58 (for 10% V_f);

$$\beta_T = \frac{1.487}{1.249}(1 + 0.3)0.416$$

= 0.644 (for 30% V_f)

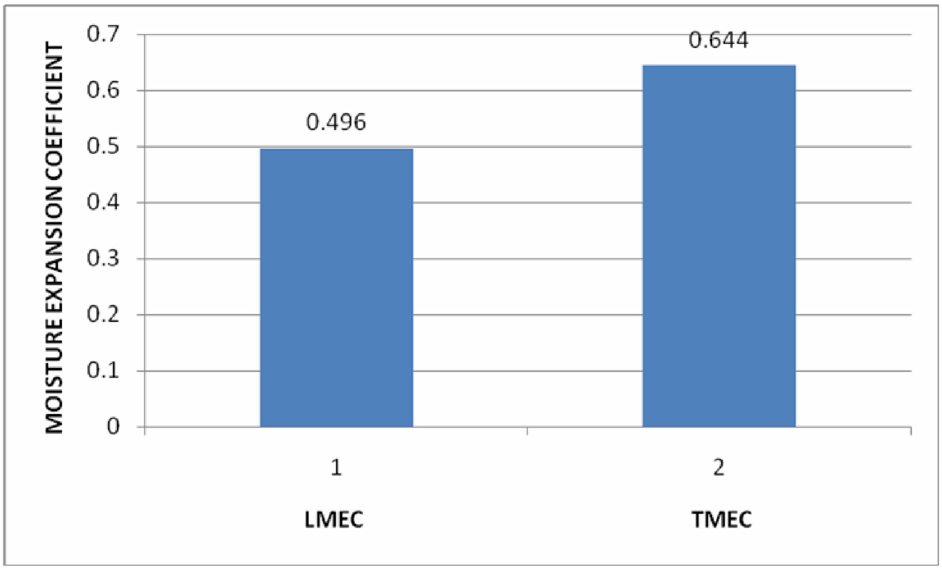

Fig. 1 Effect of V_f on transverse and longitudinal moisture expansion coefficient

(For $V_f = 30\%$)

Key: LMEC – Longitudinal moisture expansion coefficient

TMEC – Transverse moisture expansion coefficient

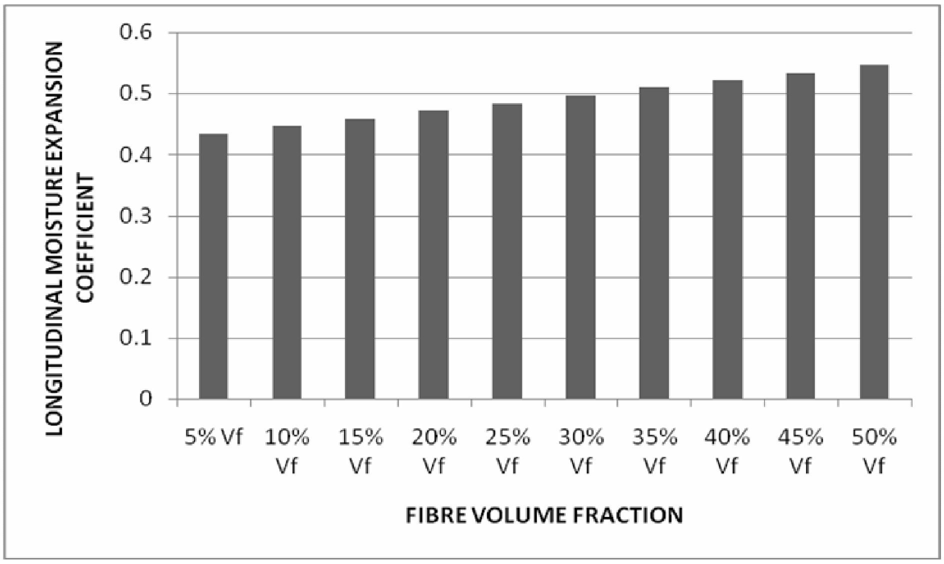

Fig. 2 Effect of volume fraction (V_f) on longitudinal moisture expansion coefficient

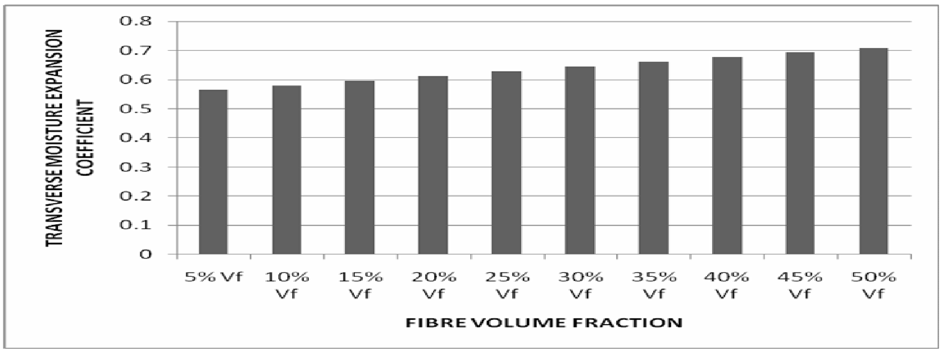

Fig. 3 Effect of volume fraction (V_f) on longitudinal moisture expansion coefficient

2.4 Discussion/Conclusion

From the results above, it could be seen that:

- Transverse moisture expansion coefficient β_T of the composite is higher than the longitudinal moisture expansion coefficient (β_L).
- The moisture resistance capacity of ukam plant fibres can be improved through: (i) Fibre treatment (i.e. changing the hydrophilic nature of the cellulosic fibres to hydrophobic. (ii)Fibrillation – splitting the fibre bundle into smaller filaments, leading to increasing surface area available for wetting by the polymer matrix.
- From the experimental data in table 1, it can be seen that moisture uptake was relatively low, which will turn out not to be such a problem.
- It was observed that the Longitudinal and tranverse moisture expansion coefficients were found to be 0.496 and 0.644 respectively

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