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Properties of Coconut, Oil Palm and Bagasse Fibres: As Potential Building Materials

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Abstract

The use of natural fibres in composite materials is attracting research interest worldwide due to the fibres ability to increase the strength, reduce environmental impact and reduce cost of the material. In this study the properties of coconut husk fibre, oil palm fruit fibre and sugarcane bagasse fibre have been investigated. Experiments on length and diameter, specific weight, tensile strength, modulus of elasticity, moisture content and water absorption tests on the fibres have been conducted to determine their properties for possible use as reinforcement in composite. It was found that different fibres have different properties and behave similarly in wet and damp conditions. The study concludes that all the fibres possess properties that are acceptable as natural fibres to be used as reinforcement in soil blocks.

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Keywords: Coconut fibre, oil palm fibre, sugarcane bagasse fibre, tensile strength, specific weight, water absorption, SEM analysis.

1. Introduction

In the last decade, considerable effort has been directed towards using various natural fibres, which are available in abundance in tropical and sub-tropical countries, as reinforcement in composites for producing cost-effective building materials with a view to have a sustainable development. Natural fibres which are usually used in weaving, sacking and ropes have good potentials to be used as reinforcement in composite materials such as soil blocks [1]. These materials have good physical and mechanical properties, provide good environmental benefits and low cost advantage for use as building material [2]. In addition, natural fibres can be used in composite materials to reduce weight, increase strength and are also very safe during handling, processing and use [1, 3]. Requirement for economical and environmentally friendly materials has extended an interest in natural fibres [4, 5].

The use of natural fibres in composite materials will not only increase the strength of the composite but also address sustainability issues [6]. In addition, these materials will not pollute the environment, utilise local skills, be available and abundant, and be low-cost. Ali [7] explained that natural fibres in composite can be applied in civil engineering for plastering, use as roofing material, slabs, boards, wall panelling systems, house construction and slope stabilization.

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In tropical and sub-tropical regions, natural fibres such as sisal, bamboo, coconut husk, sugar cane residue (bagasse), oil palm and pineapple leaves are in abundance and cheap. In this study, fibres from agro-based wastes such as coconut husk, oil palm nut fruit and bagasse which are abundant in Ghana are used. The properties of these fibres are investigated for the purpose of using as reinforcement in soil blocks for producing environment friendly and low-cost housing.

1.1. Coconut fibre

Coconut fibre also known as coir is extracted from the outer shell of a coconut fruit. Coconut plants are mainly cultivated in tropical and sub-tropical regions. In Ghana, the annual production of coconut is about 305,000 tones [8], and this generates a lot of waste in the country. Coconut fibres are generally available for use in three main ways, (1) bristle (in long fibre), (2) mattress (in short fibre) and (3) decorticated (mixed fibre lengths) [7]. The engineering use of coconut fibre is not much known, however it possesses good properties for engineering purposes. Coconut fibre dimensions vary, and are said to be dependent on the type of species, location and maturity of the coconut plant. The flexibility and rupture of the fibre is affected by the length-to-diameter (aspect ratio) of the fibre which largely determines its usage [7]. Coconut fibre consists mainly of cellulose, hemi-cellulose and lignin as its main composition which affect the physical and mechanical properties of the fibre.

1.2. Oil palm fibre

Oil palm fibres are extracted from three parts of oil palm plant, namely (1) empty fruit bunch, (2) trunk/stem and (3) the fruit nut. Oil palm originally came from the Western part of Africa in the tropical rain forest where it is processed for its fruits for consumption as edible food and oil, medicine, wine, hand craft [9] and for industrial used. The annual production of oil palm in Ghana is about 1,900,000 tones [8]. Oil palm fibres are porous, short in length and have varying diameter which affect the mechanical properties. Oil palm fibres have low cellulose content as compare to coconut and bagasse fibres, which makes it easy to extract.

1.3. Sugarcane bagasse fibre

Sugarcane bagasse is the residue obtained after extracting the sugarcane juice for sugar or wine [10]. During the processing, the sugarcane stalk is crushed to extract sucrose, and the process produces a large volume (32%) of bagasse [11]. The fibres are then extracted from the sugarcane residue; hence, bagasse fibre is easily obtained as a waste product [12]. The annual production of sugarcane in Ghana is about 145,000 tones [8]. The stalk of the sugarcane plant includes an outer rind and inner pith, the rind is made up of a hard fibrous substance surrounding a central core of pith, which is softer due to a spongy structured component [12]. Sugarcane fibre is used due to its properties as a natural filler reinforcement that has played an important role in enhancing the composites performance [13].

2. Experimental methods

2.1. Fibres

Fibres obtained from three different agricultural wastes (sugarcane residue ‘bagasse’, coconut husk and oil palm fruit residue) were used for the study. These were selected because they are among the common agricultural wastes generated in Ghana. These wastes are usually burnt which pollutes the air and affect the health of the general public.

The waste fibres have been selected as they cover a wide range of properties, and are also abundant agricultural waste materials in West Africa. They are not the only wastes in the study location from which their fibres can be used. There are other waste from agriculture products such as bamboo, sisal and rice husk which are also available. However, lack of clear methodological process of extracting the fibres, the low scale production in the study location resulted in their exclusion from the study.

2.2. Preparation of fibres

The agricultural wastes were processed to obtain their fibres. The fibres were prepared through different, but similar processes for each type. The processes have been described below.

Bagasse fibres used in the study were obtained from sugarcane residue at a local sugarcane alcohol distillery mill in Somanya, Ghana (Fig. 1a). The juice (liquid) from the sugarcane had been extracted for producing alcoholic drink leaving the residue (bagasse). The sugarcane residue was already crushed (Fig. 1b) at different sizes through the