

Strength and Fracture Toughness of Earth-Based and Natural Fiber-reinforced Composites

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Abstract

This paper presents the results of a combined experimental and theoretical study of the strength and fracture toughness of earth-based materials. They include mixtures of laterite, clay and straw that is stabilized with controlled levels of Portland cement. The compositional dependence of compressive, flexural strength and the fracture toughness is explored for different proportions of the constituent materials. Composites and fracture mechanics models are used to estimate the strength and fracture toughness of the resulting composites. The applications of the results are discussed for the design of earth-based building materials for affordable housing.

1. Introduction

Although the selection of building materials is gradually influenced by the cost and availability of robust materials [1], most countries have focused largely on the application of relatively expensive cementitious building materials that are associated with ~14% of the carbon dioxide emissions [2]. This has made it relatively difficult for poor people to afford durable homes in most developing countries. However, in most of these countries, there are large deposits of industrial, agricultural and human wastes that can be recycled into robust building materials that could make homes more affordable for a significant fraction of the world's rural and urban poor [3].

In the case of industrial wastes such as blast furnace slag, Savastano et al. [4] have shown that these can be mixed with cements to produce robust materials that reduce the amount of cement that is needed to ensure adequate strength and fracture toughness in building materials. Similarly, natural fibers such as sial, eucalyptus fiber, bamboo fiber, coconut fiber and banana fiber have been incorporated into cementitious matrices to produce durable composites that are resistance to crack growth and fracture [5]. Such composites are now been used in eco-friendly housing that include roofing elements [6] and building blocks [7] that reduce the cost of available building materials.

Recently, building materials have undergone various forms of optimization with most attention on the introduction of different types of reinforcements. A report in Forest Products Newsletter in 1986 [8] indicated that most developed countries have adopted wood fibre reinforced cement (WFRC) products obtained by Hatschek (or wet) process for building purposes. In an attempt to provide an alternative for low cost building materials, Agopyan and John [9] reported the use of natural fiber