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Tensile and fatigue properties of Jute–Glass hybrid fibre reinforced epoxy composites

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Abstract

In this study, the tensile properties and fatigue life of woven jute–glass hybrid–reinforced epoxy composite were investigated experimentally. Various types of composites with different constituents (jute, glass and hybrid composites) were prepared and tested according to ASTM (D3039 and D3479) standards. Tests included: tensile test for determining the monotonic tensile strength and modulus, and tension-tension fluctuating cyclic loading with a frequency of 5 Hz and stress ratio of 0.1 for measuring the fatigue life and stiffness degradation. The results showed that jute fibre could partially replace glass fibre within the polymeric hybrid composites towards the production of more eco-friendly composites although there was a relative decline in composite's tensile properties and fatigue life. Incorporation of jute fibre within the hybrid composite reduced the fatigue sensitivity (stiffness degradation) of the composite. A comparison between glass and hybrid composites indicates that composite's stiffness after 10 000 cycles reduced 21% (glass composites), 16% (30:70 of jute:glass hybrid composites), and 12% (45:55 of jute:glass hybrid composites). Results suggested that the eco-friendly and cheap natural fibres such as jute could be successfully hybridised with glass fibre for structures subjected to cyclic loading.

Introduction

Synthetic fibres used as reinforcements in composite materials such as glass, carbon and Kevlar fibres are commonly used in automotive and aerospace industries that need high strength and stiffness to weight ratio. Composites reinforced with such fibers, particularly glass fibers, have a detrimental impact on the environment and human's health especially at their end service life as they are not biodegradable materials. On the other hand, the common natural fibers with plant-based such as bamboo, sugar palm, kenaf, jute, sisal, hemp and flax are considered eco–friendly, low-cost, low-density, abundant and renewable [1, 2]. These fibers have been used recently to reinforce the composites instead of using synthetic fibres. Natural fiber-composites exhibit lower elastic modulus, lower tensile strength, and higher moisture absorption compared to composites reinforced with synthetic fibers such as glass [2]. Other disadvantages of natural fibers including their higher variability in mechanical properties and weak adhesive with polymeric matrices due to fiber's hydrophilic nature, relatively higher crimp (undulation), higher cavity (lumen) existence, and poor-wettability [3, 4]. Concerning mechanical properties, the tensile strengths of these fibers are only 20–50% of that of E–glass fibers [5]. Therefore, incorporation or hybridization of different fibre types in the composite could meet the need. The hybridization of proper synthetic and natural fibers in a single matrix was used mainly to supplement any lack in a certain characteristic of one fiber by other fiber [2, 6]. The natural–synthetic hybrid fiber reinforced–composites could offer reasonable mechanical properties and balanced–costs compared to a composite reinforced with an individual fiber material [7].

Hybrid composites made from jute-glass fibres/epoxy resin system may potentially be used in biomedical applications such as bone fracture plate instead of bone metallic implants, sport applications such as tennis rackets and bicycle's frame. These applications are exposed to fatigue loadings during their service life. Fatigue