AC 2007-2581: SYNTHESIS AND CHARACTERIZATION OF BIOMIMICKED STRUCTURAL COMPOSITES

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Synthesis and Characterization of Biomimicked Structural Composites

Abstract

This paper presents the preliminary results of experiments conducted on the toughening of structural composites for shatter-proof applications. Layered composites inspired by tough biological structures such as nacre were fabricated and tested in tension and compression. The results are compared with monolithic structures fabricated and tested under the same conditions. Compared to monolithic samples, mechanical testing results show greater toughness associated with higher levels of ductility for the layered composites. The effect of materials selection for structural composites was investigated. It was concluded that biomimicked structures can be designed and fabricated with both higher levels of tensile strength as well as increased ductility (resulting in higher fracture toughness). The educational implications of this work in terms of the students participation and its usefulness in the outreach programs are discussed.

Introduction

Development of tough structural materials could potentially lead to a significant reduction of fatalities and property damage during earthquakes, tornados and hurricanes. Collapse of mortar and brick type structures, caused by the dynamic shear forces of earthquake can be mitigated or completely prevented if the mortar is chosen to be a thin polymer.

Robust biomechanical structures such as bone and nacre show great fracture toughness due to their intricate designs combining a soft phase polymer with a hard phase mineral. In nacre, parallel layers of aragonite tablets (Figure 1) are glued together by an inorganic polymer (proteins and polysaccharides). If the edge of the tablets are correlated into a tessellated arrangement (Figure 1) it resembles the structure of abalone. Alternative structure is the Noncorrelated edges of the tablets leading to the structures typical of pearl oyster. Superior mechanical properties of this structure include a high strength combined with high fracture toughness. Due to the lamellar nature of the structure, properties are anisotropic. Nominal strength ranges from 194-248[1] obtained from the 3-point bend tests on abalone and oyster with higher numbers belonging to pearl oyster.

An initial elastic response is observed during the tensile loading of nacre parallel to its plates.. However, at a stress level of 110 MPa a steady state deformation (inelastic) commences that continues until fracture at 1% strain. This inelastic secondary deformation is not seen during compression loading. Rather, an elastic deformation takes place that continues to fracture at very high stresses (exceeding 400 MPa) associated with a shorter fracture strain (0.5%). When loading axis is at 45º with respect to the plates, a uniform shear stress occurs across the plates. The steady state inelastic response that commences at a shear stress of 40 MPa continues until fracture at 8% strain. The main role of inelasticity is its insensitivity to localized deformation sites that causes premature failure.