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EFFECT OF FIBER FORM AND VOLUME FRACTION ON FIBER-REINFORCED BIOMIMICKED COMPOSITES

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ABSTRACT

Biomimicked composites have shown to be superior to monolithic structural materials. However, they need reinforcement to replace conventional load-bearing structural composites. Carbon Fibers in long and short forms were used as reinforcement in biomimicked composites. Mechanical tests including four point bending were conducted to determine the effects of form and volume fraction of fibers on the fracture toughness of the biomimicked composites.

INTRODUCTION

Naturally tough structures such as nacre, bone and tooth combine hard ceramics with soft natural polymers. For mother of pearl and oyster, layers of aragonite ($CaCO_3$) are glued together by a thin layer of natural polymer resulting in a composite that greatly resists impacts. Mimicking this scheme using structural materials such as concrete with commercial glue has proven to increase the toughness of biomimicked concrete [1].

The use of fibers to reinforce load bearing structures is seen in natural products such as wood [2] and synthetic composites such as sisal fiber- [3] and hemp- reinforced structural materials [4]. Use of straw with clay to create a water-impervious crack-resistant coating for roofs and walls of mud huts go back many centuries to Egyptian early dynastic period (3100-2613 BC). The strength of mud bricks increases three-fold by adding straw [5].

The main drawback of mud huts is their collapse during modest earthquakes as evidenced by city of Bam earthquake that destroyed its citadel, a 2500-year old mud brick compound [6]. Even the steel-reinforced structures are not resistant to relatively strong earthquakes leaving room for improvement. One approach is to replace the natural fibers with more sturdy synthetic counterparts such as glass-, stone- and carbon fibers. Combined with concrete, in patterns dictated by nacre (mother of pearl and oyster) this may greatly enhance the dynamic shear-resistance of the composites during earthquakes.

Carbon-fiber reinforced composites have been extensively used for high-strength low-weight structural applications such as marine, auto and space industries. Carbon fiber is now available as replacement for steel rebar where corrosion products cause deterioration of concrete structures in coastal areas and in chlorinated atmospheres. ACI has two specifications: ACI 440.5-08 [7] and ACI 440.6-08 [8] for the use of carbon- and glass fiber reinforced polymer bar materials in reinforced concrete. Although the use of composite bars as replacement for steel is now practiced for specific applications, it may not be appropriate for robotic construction where structures will be built by rapid prototyping techniques. This paper will look into the effect of combining the desirable properties of biologically-tough structures with those of reinforced composites.