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FABRICATION AND CHARACTERIZATION OF BIO-INSPIRED STRUCTURAL COMPOSITES

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ABSTRACT

This paper presents the results of mechanical tests performed on bio-inspired structural composites. The details of synthesis process, loading configurations, testing conditions are discussed. Results of the tests clearly show the superiority of the biomimicked layered composites made from concrete and polymer, in terms of toughness over their monolithic counterparts. The implications of the results and their impact on construction technology will be elucidated.

INTRODUCTION

Tough structural materials are desirable for applications such as residential and commercial buildings. Tough structures will mitigate loss of life and property caused by earthquakes, tornados and hurricanes. The main culprit in natural disasters is the presence of dynamic shear forces that demolish brittle brick and mortar buildings. One way to make tough materials is to mimic naturally tough structures such as nacre. Oyster and mother of pearl shells combine hardness of aragonite with the softness of natural polymers. The result is a tough structure with nominal strengths of 194-248 MPa [1] reported for 3-point bend tests performed on abalone and oyster.

The mechanism of toughening of nacre has been debated to be the maximization of inelastic strain, nanoscale asperities causing mechanical interlocking [1] or the continuity of aragonite single crystal tablets through bridges over the polymer layers [2].

Structures made with designs taken from nature include micro-laminated ceramic-metal [3-5], ceramic-organic, as well as organic-organic composites [6]. Biomimicked ceramics synthesized include B_4C layered with Al [7], SiC layered with Al and B_4C layered with polypropylene [3, 8, 9]. Hydroxyapatite scaffolding [10] is an example of biomedical application of biomimicked structures.

It is possible to apply natural schemes of nacre to structural materials by layering hard materials such as concrete with soft polymers such as glue [11]. Mechanical tests on biologically inspired composites show greater toughness associated with composites made of concrete and glue [11]. This paper describes dynamic shear tests performed on these structures

EXPERIMENTAL PROCEDURE

Structural composites tested here were made of layers of concrete separated by thin layers of polymer. Details of the preparation method for the test specimens are presented in Ref [11]. A brief description of the samples follows. There were three composite specimens along with a fourth monolithic control one. They were made with three types of polymers and were named accordingly: Concrete-Gorilla-Glue (GG), Concrete- Bonding Adhesive (CBA) and Concrete-Liquid-Nail (LN). Materials properties are presented below:
Cement: Quikrete™ Quick Setting Cement # 1240 with a compression strength of 20-44 MPa.