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Research paper

Compressive mechanical properties of demineralized and deproteinized cancellous bone

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ABSTRACT

A method to completely demineralize and deproteinize bone was used to investigate the mechanical properties of either the mineral or protein phase in cancellous bone and compared to an untreated one. Compression tests on cancellous bovine femur and elk antler (*Cervus elaphus canadensis*) were performed on demineralized, deproteinized, and untreated samples in an air-dry condition. Results showed that the elastic modulus and compressive strength of the demineralized (protein only) and deproteinized (mineral only) samples were far lower than that of the untreated ones, indicating a strong synergetic effect between the two phases. Experimental data showed that the demineralized, deproteinized, and untreated samples can be modeled as cellular solids, with the strong dependence of mechanical properties on the relative density. Deformed samples were examined under SEM and different failure mechanisms were observed. Plastic buckling was observed in demineralized samples while brittle crushing was found in deproteinized ones.

1. Introduction

Bone is a composite material of a fibrous biopolymer (type-I collagen) and a mineral phase (carbonated hydroxyapatite) assembled into a complex, hierarchical structure. There are two types of bone, cortical (or compact) bone and cancellous (or trabecular) bone. The major difference between the two is in their relative density, the apparent density of bone divided by that of its solid material. Bone with a relative density less than 0.7 is classified as cancellous bone (Gibson, 1985; Gibson and Ashby, 1999). The density and morphology of cancellous bone depends on the external stress it experiences (Gibson and Ashby, 1999). A low-density, rod-like structure develops where the stress is low; whereas a high-density, plate-like structure presents where the stress is high. The cancellous bone is surrounded by compact bone, which is denser (~2 g/cm^3), forming an architecture similar to synthetic sandwich composites.

The mechanical properties of cancellous bone have been vastly studied and summarized by a number of reviews (Gibson, 1985; Keaveny and Hayes, 1993; Gibson and Ashby, 1999; Keaveny et al., 2001; Gibson et al., 2010). Experimental studies on cancellous bone have addressed mechanical properties as a function of apparent density (Carter and Hayes, 1976, 1977; Rice et al., 1988; Hodgskinson and Currey, 1992), anatomic location (Goldstein, 1987), loading direction

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