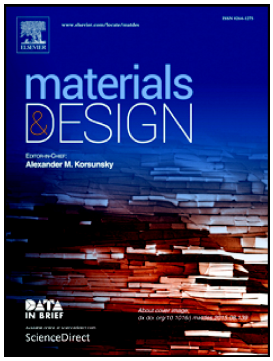

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Crumpled Paper Sheets: Low-cost Biobased Cellular Materials for Structural Applications

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ABSTRACT

Several low-density crumpled paper-based materials were fabricated by varying both the volume fraction and the geometry and mechanical properties of paper sheets. Their 3D architecture was investigated using X-ray microtomography. Microstructure descriptors such as the pore size distribution, the mean curvature distribution and the volume fraction of ordered domains were finely analyzed. Their mechanical properties were also assessed using uniaxial compression tests. Our results showed that crumpled materials exhibited a particular porous microstructure with a reproducible mechanical behavior between foams and entangled fibrous materials. Their compressive behavior was characterized by successive elastic, strain-hardening and densification regimes. The effects of the geometry, microstructure and mechanical properties of the sheets on the process-induced microstructures and mechanical performances were discussed. In particular, a micromechanical approach was used to estimate the role of ridges and ordered domains on the mechanical properties of crumpled papers. The evolution of their Young's moduli and yield stresses were studied as a function of their relative density and compared with experimental data available in the literature for other cellular materials, showing that crumpled papers are promising renewable alternatives to standard polymer foams for several engineering applications, due to the proper combination of mechanical properties, porosity, cost, and easy fabrication.