Loops of circularity: Rethinking Construction Through Circular Fabrication and material design

Abstract

The circular economy is increasingly influencing sectors such as automotive, packaging, and building construction. The rise of the circular economy is driven by the generation of large volumes of waste that are challenging to manage and often end up in landfills—wasting not only materials but also the embedded energy and resources, thereby contributing to a higher carbon footprint and environmental damage. Circular economy principles aim to retain materials and components in the application loop for as long as possible through recycling, upcycling, reprocessing, and repair. At the end of multiple life cycles, energy and material recovery strategies can further minimize environmental impact and carbon emissions.

This poster presents two case studies from the building and construction industry that apply circular economy approaches: (1) recycling of precast concrete molds using extrusion and big area additive manufacturing (BAAM), and (2) fabrication of recyclable, carbon-neutral or carbon-negative wall panels.

In the first case, wood flour (WF)/polylactic acid (PLA) and carbon fiber (CF)/acrylonitrile butadiene styrene (ABS) pellets were 3D-printed into precast concrete molds, replacing heavy, short-lived wooden molds. After use, the molds were shredded, extruded, and reprinted for subsequent concrete casting. This cycle was repeated 4–5 times (and aimed for 7 cycles), with only marginal losses in mechanical properties and flow behavior during extrusion and additive manufacturing.

In the second case, polypropylene (PP) was reinforced with carbon fiber, hemp fiber, and multi-walled carbon nanotubes (MWCNTs) to produce fully recyclable wall panels. Fabrication involved three steps: (1) fabrication of five non-woven mats (500 GSM) using wetlaid containing PP fibers, 2–3 inch long hemp fibers, and 1 inch long carbon fibers; (2) application of a pre-measured MWCNT dispersion layer followed by drying; and (3) stacking MWCNT coated non-woven mats followed by compression molding at 220 °C (applied pressure of 25 tons) to produce 12 × 12 inch panels. The panels were characterized for mechanical and acoustic performance, then shredded and remolded for the same application. Mechanical testing of the recycled panels is ongoing."