Recyclability of Large-Scale 3D Printed Formwork

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Abstract

Large-scale additive manufacturing has become increasingly popular in both research and industrial settings. This increase in popularity and usage has led to an increase in waste material being disposed of in landfills. The purpose of this work is to address the waste and propose a different end-of-life treatment, other than disposal.

The use of large-scale extrusion-based 3D printing as a manufacturing method for precast concrete formwork will lift the geometric constraints of traditional formwork, lessen labor costs due to the process being a form of automated manufacturing, and allow for material recycling after the useful life of the forms.

Carbon fiber–acrylonitrile butadiene styrene (CF-ABS) and wood flour–amorphous polylactic acid (WF-aPLA) are the materials being evaluated in this project. These materials are printed into rectangular concrete forms, using the Ingersoll Masterprint at the University of Maine's Advanced Structures and Composites Center.

Baseline material properties of the first set of printed forms were determined using differential scanning calorimetry (DCS), thermogravimetric analysis (TGA), a modified ASTM D3039 standard for tensile specimens, and scanning electron microscopy for fiber length determination. This baseline will be used comparatively for all future recycling efforts, to determine any degradation in material properties. This material will now be shipped to Oak Ridge National Laboratory, to be made into new feedstock material. The feedstock will then be used to print additional (i.e., recycled) formwork.

This research can potentially transform the use of precast concrete into a more sustainable and economically conscious choice, by showing the circular lifecycle of 3D-printed thermoplastic composite forms. Additionally, the use of large-scale 3D printed formwork could broaden the applications of precast concrete by removing the geometric limitations of formwork.

Figure 1: CF-ABS and WF-aPLA 3D Printed Forms

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