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Concrete Metamaterials: Geometry, Composition, and Production

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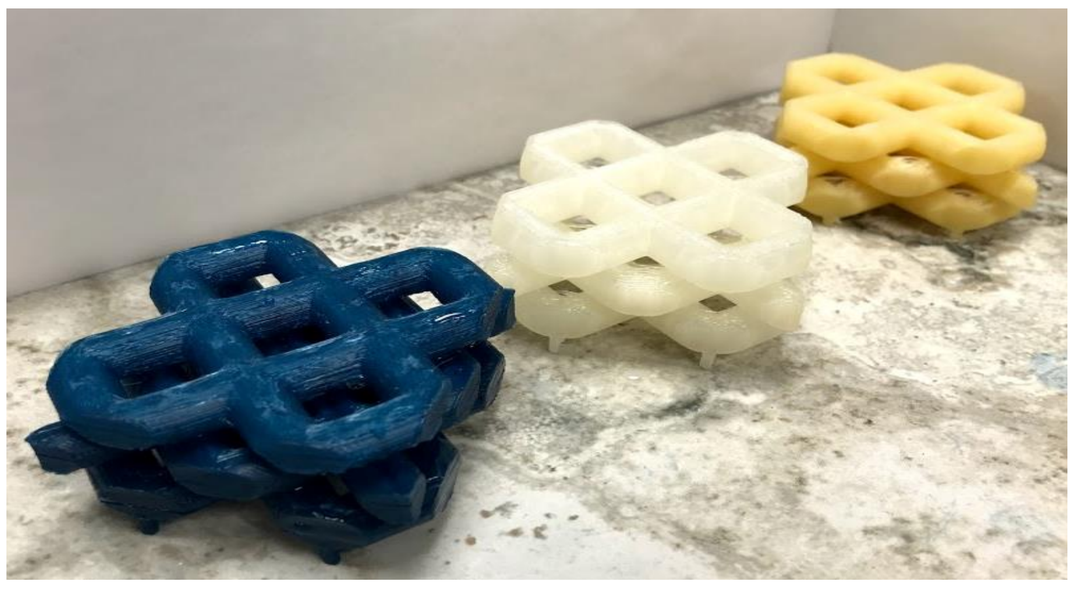
Introduction

Additive manufacturing is a fast-advancing technology due to its ability to produce complex geometries in a short period of time at a relatively low cost. 3-D printing can be used to create either the parts themselves or the molds for a part. On this research, 3-D printing was used to print a mold for the concrete to be poured into in order to create a concrete lattice structure.

Method

A mold was 3D printed using a previously created computer model for it. This mold was printed using three different materials, which were Machinable Wax (blue mold), Natural PVA (yellow mold), and PolyCast (white mold). After the mold was printed, a box was built around it, and the concrete was poured. After being cured, different techniques were used in order to remove the molds and find the most viable material to use. This cleaning completed the process of obtaining the lattice structure.



Key Findings

Different patterns for the lattice structure were considered but the pattern shown was found to be the better one. The cleaning techniques used were:

- Melt the wax at around 140 ℃ in an oven
- Submerge the one that used the Natural PVA in water since the material is water soluble
- Burn the PolyCast at temperatures above 230 ℃

The Machinable Wax was therefore found to be the most viable material since it can be easily removed reused after melted, and it melts at a low enough temperature that does not damage the concrete, which is not the case for the PolyCast. The PVA was not viable because it breaks the concrete when dissolving. The previously used PLA required big amounts of acetone and a long time to be dissolve and cleaned, making the production more difficult.

Conclusions

This type of additive manufacturing can have many useful applications in many industries, such as the concrete one. The characteristics of concrete lattice structures are:

- Lower compressive strength than solid concrete
- Lighter due to the use of less material and increased porosity
- Good energy absorption, such as thermal or impact energies.

Therefore, this concept could be used in houses where the concrete does not need to be extremely strong, providing also a good insulation.

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