

3D Printing of Multifunctional Foam Concrete

Modern construction requires multifunctional materials. These materials should exhibit not only mechanical properties but also multifunctional properties like light weight, thermal insulation, acoustic insulation, fire resistance, freeze-thaw resistance etc. Considering these peculiar properties, the materials can be used in both structural and non-structural applications like panels and blocks for partition walls, false walls, suspended false ceilings, external environmental infills and light weight slabs. Foam concrete could be one of the viable solutions to achieve these goals. It is a unique, non-structural and low-cost filler with different properties such as low density, low thermal conductivity, high acoustic insulation, good fire resistance, good freeze and thaw resistance and high energy absorption capacity. These properties of foamed concrete could depend on foam density, size of the foam bubble and spacing between the bubbles.

Although these properties of material could be achieved in a precast industry, using an automated extrusion process like 3D printing could reduce material wastage, increase the productivity, eliminates the need for formwork, optimize the cost elements like labor, material, design and planning costs in comparison to conventional construction methods.

3D printing of foam concrete poses many challenges during and after the printing. High flowability restricts the buildability whereas the more stiffness leads to collapsing of the foam bubbles. Foam collapse is also very common due to the use of incompatible admixtures and using admixtures in high dosage. These properties of foam concrete are highly dependent on the volume of the foam added to the mortar, stability of the lamella around air bubble and spacing between the air bubbles. These parameters may vary with type of foaming method (mixed or pre-foaming method), type of the surfactant used (synthetic or natural), type of stabilizer used and pressure applied during the extrusion process. Hence, there is a need to address these issues from 3D printing prospective.

Objectives:

The main objective of this study is to design the foam concrete mixes that are extrudable and buildable with less variations in target densities and achieving the required rheological and mechanical properties.

Challenges:

- Foam concrete is a highly flowable mixture due to the presence of air bubbles that gives ball bearing action to attain the flowability. Printable mixes not only require the flowability but also thixotropic nature.
- Pumping and extrusion of foam concrete with less variations in target densities. Since from literature, it is evident that pumping and extrusion have severe impact on air void system (i.e. both air content and spacing factor decreases significantly) in concrete.
- With decrease in density, self-weight of the foam concrete also decreases. Decrease in the self-weight effects the buildability of mixture. Buildability is retaining the shape of printed layers under its self-weight with less deformation.

Deliverables:

- ✓ Development of printability window for 3D printing of foam concrete with industrially available rheological test setups and improving the robustness of the mix with the addition of different mineral and chemical admixtures.
- ✓ Defining the variations between printed and casted foam concrete in terms of mechanical properties and thermal properties for the similar densities.
- ✓ Development of a functional gradient mix design for 3D printed foam concrete (with varying densities in a single structure by varying the volume of foam during the printing process).