

ABSTRACT:

Comparative Study on Process Anisotropy, Permeability and Microstructure of Self-activated Cementless Printable Mortar

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This research examined the effect of the additive manufacturing fabrication technique on the hardened properties of an optimized cementless ternary binder mortar. The mechanical characteristics, durability, and microstructure of 3D-printed (3DP) specimens were systematically compared with those of conventionally mold-cast (MC) specimens made from the same material composition. The findings established the fabrication technique as the primary factor dictating performance. Compared to the isotropic MC specimens, 3DP specimens showed substantially lower compressive strength, which was reduced by over 15% when loaded parallel to the printing direction (X-direction) compared to perpendicular loading (Z-direction). This weakness was ascribed to deficient interlayer adhesion.

Durability assessments revealed that 3DP specimens exhibited a more permeable pore network, as confirmed by their significantly higher water absorption and chloride ion diffusion coefficients. Scanning electron microscopy analysis revealed a dense and uniform microstructure in self-activated cementless specimens characterized by well-developed ettringite formations. In contrast, Optical microscope imaging of the 3DP interlayer regions revealed considerable macroporosity and inadequate layer-to-layer adhesion between the printed layers. The 3D printing technique inherently generated structural anisotropy and porosity, thereby compromising the mechanical and durability performance of the cementless mortar. The material properties of the 3DP structures were ultimately controlled by these weak interlayer boundaries, which nullified the optimized properties of the base material.

Keywords: 3D Printing, Anisotropy, Diffusion Coefficient, Microstructure

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