ABSTRACT

This dissertation investigates how printing parameters and interfacial properties influence the long-term mechanical performance of 3D-printed concrete (3DPC). Although additive manufacturing in construction offers material efficiency, automation, and design flexibility, the resulting layered microstructure and interfacial heterogeneities can significantly affect mechanical properties and time-dependent deformation. This research systematically evaluates these effects and clarifies how extrusion parameters, interlayer bonding, and microstructural variations impact 3DPC's durability under sustained loads.

A central focus is on quantifying 3DPC's creep behavior compared to conventionally cast concrete. Experiments show that 3DPC exhibits greater creep compliance, particularly at early loading stages, due to the layered microstructure and localized imperfections that heighten deformation susceptibility. However, this study could not find a strong macroscopic anisotropy in creep across loading directions. By analyzing regional deformations within printed elements, the study reveals that layer positioning influences strain accumulation, underscoring the importance of optimized deposition strategies. Further investigations using Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) examine phase distribution between filament core and interface in 3DPC. Results reveal a paste-rich interface with increased porosity, influenced by the lubricating layer effect. Optical microscopy confirms aggregate migration toward the core, reinforcing the role of shear-induced material separation in phase distribution and mechanical performance.

To broaden the scope, the creep behavior of 3D-printed polymers (Tough PLA) is also explored, revealing a similar reliance on layer bonding and interfacial shear strain. Insights from polymer-based additive manufacturing may inform future 3DPC design strategies—particularly in mitigating creep and enhancing interlayer adhesion through different printing patterns. These findings underscore the need for new creep models tailored to 3DPC's anisotropy and microstructural complexity, along with optimized printing parameters. Overall, this dissertation offers a pathway toward more reliable, durable 3D-printed structures across a range of materials and applications.