

Master's Thesis Project Proposal

Durability Assessment of the Interface Between 3D-Printed and Cast Concrete

Supervisor

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Start: Immediately / by arrangement

Background

Three-dimensional concrete printing (3DCP) is becoming increasingly relevant in the construction sector due to its material efficiency, geometric freedom, and high degree of automation. Recent developments include hybrid structural systems where 3D-printed concrete acts as permanent formwork for cast-in-place reinforced concrete (RC). Such systems combine the advantages of digital fabrication with the structural performance of conventional RC and are expected to play a key role in future construction.

While the mechanical interaction between printed formwork and cast concrete has recently gained research attention, the durability behaviour of the printed–cast interface remains almost completely unexplored. Yet, the interface represents a potential weak zone where:

- differences in porosity and moisture content,
- process-induced anisotropy,
- time gaps between printing and casting,
- and curing variations

may lead to preferential pathways for carbonation, chloride ingress, moisture transport, freeze–thaw damage, or fire-induced degradation. If not properly characterized, these mechanisms may strongly influence the long-term bond, stiffness, and service life of hybrid concrete structures.

Existing studies on durability typically focus either on 3D-printed concrete alone or on cast new-to-old concrete interfaces—but no systematic study exists for the printed–cast interface. This Master thesis aims to close this gap.

Objective:

To investigate the durability-related behaviour of the interface between 3D-printed and cast concrete by conducting a structured literature review, defining appropriate test methods, preparing and exposing specimens, and evaluating the impact of different degradation mechanisms on interfacial performance.

Main Tasks

1. Literature Review – Durability of 3D-Printed Concrete
 - Summarize the current knowledge on carbonation, chloride ingress, freeze–thaw resistance, moisture transport, and fire exposure of 3D-printed concrete.
 - Identify process parameters influencing durability (layer interfaces, thixotropy, curing, porosity, anisotropy).
2. Literature Review – Durability of Cast Concrete & New-to-Old Interfaces
 - Review durability mechanisms relevant to conventional concrete and cold joints.
3. Gap Analysis – Durability of Printed–Cast Interfaces
 - Identify which mechanisms are expected to be critical at the hybrid interface.
 - Evaluate whether existing test protocols can be applied or require adaptation.
4. Definition of Test Programme
 - Select durability tests suitable for the printed–cast interface (e.g., chloride ingress, carbonation, moisture transport, freeze–thaw, fire exposure).
 - Define specimen types, sample preparation and interface configurations.
 - Justify the chosen tests and expected outcomes.
5. Participation in Specimen Manufacturing
 - Assist in printing the concrete elements.
 - Prepare and cast the bonded interfaces.
 - Perform curing and pre-conditioning steps.
6. Execution of Durability Tests
 - Conduct durability exposures (depending on test plan).
 - Prepare cross-sections and measure degradation indicators (e.g., carbonation depth, chloride profiles, mass loss, spalling, microstructural changes).
7. Evaluation of Interface Degradation
 - Assess whether degradation concentrates at or propagates along the interface.
 - Analyze differences between printed, cast, and interfacial zones.
 - Interpret the impact of degradation on potential long-term bond behaviour.
8. Conclusion & Practical Implications
 - Discuss findings in the context of hybrid 3DCP–RC structures.
 - Provide recommendations for process improvements, mix design, or surface preparation strategies.

Requirements

- Interest in concrete technology, material durability, and additive manufacturing
- Motivation for hands-on laboratory work and systematic testing
- Ability to work independently and critically evaluate literature
- Basic knowledge of durability mechanisms in cement-based materials (preferred)
- Team-oriented working style
- Familiarity with mechanical testing (preferred)

Language for the written version:

English / Deutsch

Literatur

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- [6] van der Putten, J., Volder, M. de, van den Heede, P., Deprez, M., Cnudde, V., Schutter, G. de, van Tittelboom, K.: Transport properties of 3D printed cementitious materials with prolonged time gap between successive layers. *Cement and Concrete Research*, vol. 155, 106777 (2022). doi: 10.1016/j.cemconres.2022.106777
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