

Design Criteria for Sustainable Sprayed Concrete Structures: Establishing Equivalence with Cast-in-Place Concrete

Background and purpose

The project aims to establish the scientific and engineering basis for using sprayed concrete as a viable alternative to conventional cast-in-place reinforced concrete in permanent load-bearing structures. While sprayed concrete (shotcrete) is widely used in North American (NA) infrastructure projects and increasingly requested by contractors due to faster construction, reduced formwork requirements, lower costs, and improved constructability, European designers still lack validated design criteria and performance documentation.

A key concern is whether sprayed concrete can provide structural and durability performance equivalent to traditional cast concrete, particularly when reinforcement is present. The research focuses on understanding the implications of production-related defects, such as voids behind reinforcing bars caused by rebound or inadequate consolidation, which may affect bond strength, crack control, durability, and long-term service life. The overall goal is to provide designers with reliable design guidance and quality criteria, enabling confident specification and approval of sprayed concrete solutions for major infrastructure applications.

The methodology combines advanced experimental testing, non-destructive imaging, and durability assessment to evaluate the performance. Test specimens include conventional cast concrete, sprayed concrete, and sprayed concrete containing intentionally introduced defects. Reinforced wall mock-ups will be constructed and subsequently cut into specimens for mechanical and durability testing.

The research programme includes mechanical testing, durability investigations, chloride migration, carbonation, porosity) and X-ray Computed Tomography (XCT) to quantify internal voids and assess concrete quality non-destructively. Furthermore, fibre-optic sensing will be applied to monitor strain development and bond-slip behaviour between reinforcement and concrete.

Results will be evaluated against existing design provisions, particularly Eurocode 2, to determine whether current design models remain applicable or require modification for sprayed concrete applications.

The project is a collaboration between the Technical University of Denmark (DTU), COWI Denmark, and COWI Norway. DTU provides expertise in structural mechanics, materials science, advanced testing, and imaging technologies, while COWI contributes practical design experience and industry implementation perspectives.

The project will be led by Jesper Harrild Sørensen (DTU), supported by Charilaos Paraskevoulakos (DTU), Anders Hedegaard Jensen (COWI), Oda Tjetland (COWI Norway), Carola Edvardsen (COWI) and Brad Pease representing COWI NA. A one-year postdoctoral researcher will conduct most of the research activities. An international advisory board including representatives from the Norwegian Public Roads Administration and SINTEF will provide strategic guidance and ensure practical relevance. The project is planned from Q3 2026 to Q1 2028.