Towards a Complete Modelling Tool to Optimise Solid Concrete Structures

A Path to Reduced Emissions and Resource Consumption

The Challenge of Sustainable Construction

The construction industry is a major contributor to global CO2 emissions. To achieve a sustainable development of the built environment, we need technical solutions that can significantly reduce CO2 emissions and the consumption of non-renewable raw materials. In this context, there is a potential for huge material reduction if we can improve the methods to design solid concrete structures, such as bridge foundations and similar massive structures.

Complete Design and Modelling Tool

A complete design and modelling tool must enable the engineers to predict how a structure will react to both extreme and everyday loads—referred to as ultimate loads and service loads, respectively. The goal is to minimise the risk of collapse and significant deformations and cracking. In a previous innovative research project conducted in collaboration with DTU, COWI has developed a computer-based tool to design optimal solid concrete structures. However, the tool is currently only able to consider ultimate loads. At this point, there is no efficient method available to accurately predict deformations and cracks in solid concrete structures under service loads.

To address this shortcoming, this research project will develop effective models and concepts to analyse the behaviour of solid reinforced concrete structures when subjected to service loads. This will in the future provide engineers with a complete tool that is able to consider the ultimate loads as well as the service loads in an integrated manner.

Research Methodology

Experts from DTU and COWI are partners in the project, which is organised into three work packages. The first package establishes a computer-based concept to model how solid structures deform and crack when subjected to service loads. The innovation in this modelling concept involves a special mathematical formulation of the problem, so that it can be solved efficiently by use of a technique called convex optimization. The second package deals with detailed mechanical modelling at the material point scale, examining how a cubical unit of cracked reinforced concrete behaves under complex stress conditions. The findings at the material point level will be implemented into the mathematical formulations of the first work package to obtain accurate and realistic predictions of the structural response. Lastly, the third work package is dedicated to experimental tests to inspire the modelling work and confirm its accuracy.