Complex 3D concrete structures – Computer-based calculation tool and experimental studies

Many of the structural elements of bridges are solid reinforced concrete structures. Examples include pile tops, anchor blocks and foundations. Given their volume, these elements account for a significant share of the total quantity of materials and therefore have a large impact on construction costs as well as the environmental footprint/CO_2 emissions. Solid structures are characterised by the ability to carry loads by means of so-called 3D stress states. That means that their mechanical behaviour is three-dimensional. This spatial behaviour is far more complicated than the behaviour of plane structural elements such as beams and sheets.

In practice, calculation and dimensioning of solid concrete structures often involve applying methods that were primarily developed for plane structural elements. This is due to a lack of knowledge of the material's mechanical behaviour and a lack of recognised calculation methods for concrete structures with 3D stress states. This lack entails that the material used often exceeds the material required when using a more rational design method dedicated to solid structures.

For this project, we will set up a computer-based concept for modelling and calculation of solid concrete structures. The purpose is to develop computer programs that can automate the design and analysis process and assist the engineer in determining the load-bearing ability as well as the optimum design (while minimising material consumption). The theories and technologies that we will use to set up the calculation concept are: Theory for ideal-plastic materials, modern mathematical optimisation methods as well as an element method concept.

A significant part of this project is to ensure that the developed calculation concept can be used in a sensible manner. In other words, we will ensure that the calculation results are reliable. For this purpose, on this project, we will obtain the necessary knowledge basis regarding the mechanical behaviour of reinforced concrete in 3D stress states. This will be achieved via analytical studies and experimental studies. The experimental studies will consist of tests involving representative sections of structural units as well as full-scale tests involving solid structures. The result of these studies will be used to validate the computer calculations and to delimit the sphere of application of the developed calculation concept.

The project findings may enable a shift in paradigms in how engineers calculate and design solid and complex concrete structures. This will likely lead to large time and material savings.