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Stochastic Modeling of Fiber-reinforced Ultra High Performance Concrete based on 3D Image Analysis

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Desirable properties of concrete in buildings are high compressive and tensile strength and load-bearing capacities. Ultra High Performance Concrete (UHPC) is characterized by a high compressive strength. The load-bearing capacity and the tensile strength can be increased by adding steel fibers to the concrete. The orientations and the positions of the fibers in the concrete considerably determine its properties. For instance, the load-bearing capacity is maximal if the direction of the loading force is perpendicular to the fiber orientation. A homogeneous distribution of the fibers in the concrete leads to a homogeneous load-bearing capacity.

The orientations and positions of the steel fibers depend on many parameters in the production process. Length, diameter and volume fraction of the fibers, the amount of superplasticizer, the pouring direction, and the formwork for the concrete are just a few examples of these parameters. To investigate these dependencies, a large number of samples of fiber-reinforced UHPC with varying parameters was produced. The samples were imaged by using micro computed tomography (μCT) and the fiber system was reconstructed by a suitable segmentation algorithm.

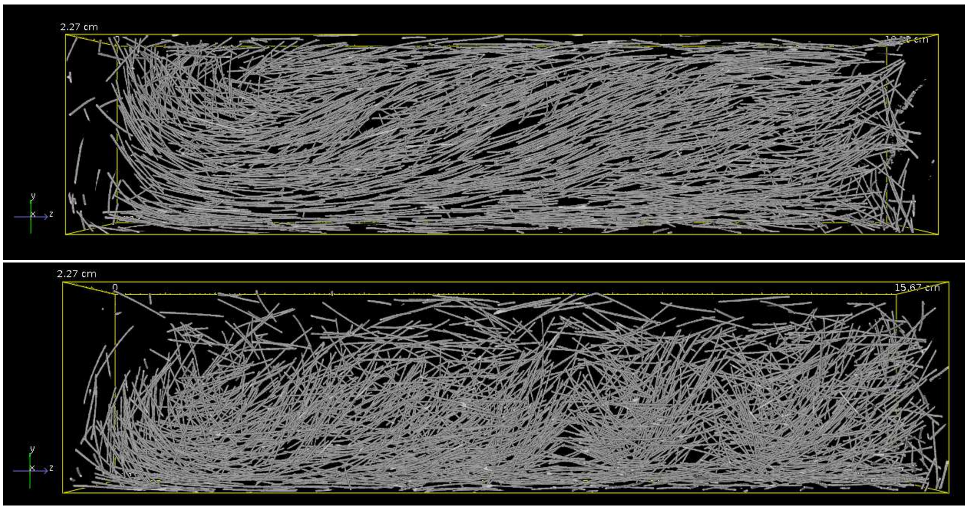

Figure 1: Visualisations of reconstructed tomographic images of a steel fiber-reinforced UHPC. The steel fibers in both samples have a diameter of 0.3 mm and a length of 12 mm. The volume fraction of fibers in the UHPC is 1%. In the sample in the bottom 20% more superplasticizer was used.

Statistical analysis showed that the fiber diameter and the amount of superplasticizer have an effect on the orientations and the spatial distribution of the fibers (see Figure 1). Furthermore, the orientation of the fibers changes depending on their position in the UHPC. In bending tests, the load-bearing capacity of the fiber-reinforced UHCP is measured. CT imaging additonally allows for an investigation of correlation between crack locations and the local fiber geometry. Finally, a method for predicting the mechanical properties of the fiber-reinforced UHPC using a stochastic model is outlined.