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TOWARDS BENCHMARK CASES FOR COMPUTATIONAL FLUID DYNAMICS FOR CASTING OF FIBER CONCRETE

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ABSTRACT

In fiber concrete the mechanical properties are partly determined by the orientation and alignment of the fibers. The fiber orientations depend largely on the casting process, formwork form, formwork surface, manual intervention and vibration. It is therefore important to be able to predict fiber orientations by simulating the casting process using computational fluid dynamics. Calibrating the fluid dynamics program is a problem, as the results not only depend on the rheological properties of the fluid-matrix, but also on the initial fiber orientations. In the poster, important aspects of designing benchmark cases for calibration and testing of fluid dynamics simulation for predicting fiber orientations are discussed.

Keywords: fiber orientations, fiber concrete, casting, computational fluid dynamics.

INTRODUCTION

Recently, several experimental studies established that it is possible to obtain fiber concrete with improved strength and durability. The main function of fibers is to bridge the microcracks in the concrete and to provide better ductility The properties of the fiber concrete depend on the concrete recipe, the flow of the fresh concrete into the formwork, possible vibrating of the concrete and the fiber orientations. The fiber orientations are largely influenced by the flow of the concrete, which also depends on the formwork surface quality. A rough, sticky surface can produce a different fiber alignment than a smooth, non-sticky surface.

The flow of the fresh concrete mass can be simulated using computational fluid dynamics (CFD), in which the concrete is approximated by a Bingham-plastic model. Recently benchmark cases have been proposed to calibrate CFD simulations of concrete without fibers. In the case of fiber concrete, also the spreading and orientational distribution of the fibers should be simulated. The fiber orientations in the fluid can be simulated by coupling an equation for the fiber orientation distribution to the Navier-Stokes equations.

The experimental verification of the simulations of the fiber orientations is difficult, as concrete is opaque and the fiber orientations can only be measured in the hardened concrete, e. g. by x-ray computed tomography or image analysis of slices. To be able to observe the fiber orientations during the flow, experiments were performed in which the opaque concrete was replaced by a transparent matrix with similar rheological parameters as the fresh self-compacting concrete, see Fig. 1. In the poster, these experiments will be compared to the simulations.

RESULTS AND CONCLUSIONS

The results from the experiments of casting process of a transparent polymer solution which contains fibers show that formwork surface quality affects on fiber orientation and its distribution. Furthermore, the conditions of casting, like the velocity of the casting process of fresh concrete, angle and slope of the pipe, can affect the fiber orientations as well. When defining the benchmark cases for calibrating flow simulation software, these parameters need to be considered.

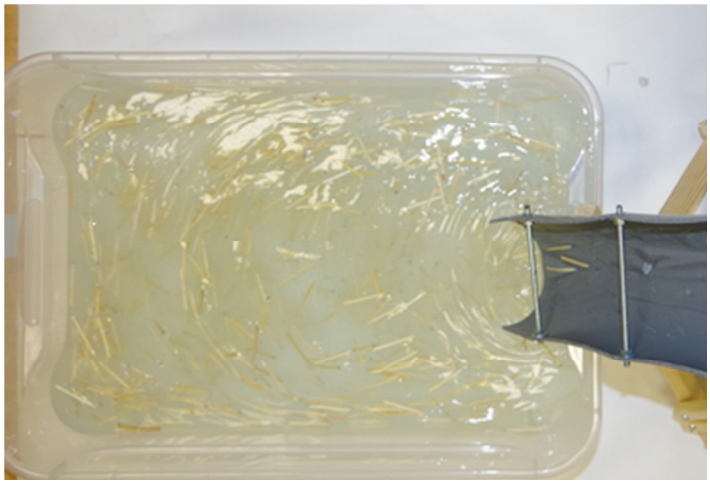

Fig. 1 - Casting experiment with fibers in polymer solution

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