Simulation of Fresh Concrete Flow

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Simulation of Fresh Concrete Flow

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Introduction

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What are the final objectives of the extensive research, which has been carried out in the last fifty years on rheology of fresh concretes?

A researcher answer could be: “the understanding of the correlation between mix design and rheological properties” or “the ability to correctly measure and quantify the rheological properties of concrete”. These are of course points of great interest but a practitioner would however probably answer: “the ability to predict whether or not a given concrete will correctly fill a given formwork”.

An analogy with the state of knowledge in the hardened concrete research field can be made: a lot of work has been indeed carried out in order to understand the correlation between mechanical properties and mix design and many tests have been developed in order to measure these mechanical properties (mechanical strength and delayed deformations for instance) but, on the other hand, many developments were also carried out in the field of structural engineering in order to correlate the needed properties of the concrete to be cast with the structure to be built. This last step has been missing for years in the rheology field. Only recently, researchers from various part of the world have started to work on casting prediction tools.

During the last thirty years, concrete has been industrially mutating from a soft granular medium to a proper non-Newtonian fluid. To benefit from the full potential of the modern fluid concretes such as Self-Compacting Concrete (SCC), prediction tools of the form filling taking into account the properties of the concrete, the shape and size of the structural element, the position of rebars, and the casting technique are needed. Although a lot of progress has been made in the field of fluid concretes, we must not forget that the most suitable concrete to cast a given element is still a concrete fluid enough to fill the formwork but not more. Additional and thus useless fluidity will always have a cost either in terms of super-plasticizer amount, loss of mechanical resistance or risk of segregation. Just as numerical simulations of concrete structures allow a civil engineer to target a minimum needed mechanical strength, casting prediction numerical tools could allow the same engineer to target a minimum workability that could ensure a proper filling of a given formwork.

Computational modeling of flow could therefore be used for simulation of *e.g.* total form filling and detailed flow behavior as particle migration and formation of granular arches between reinforcement ("blocking"). But computational modeling of flow could also be a potential tool for understanding the rheological behavior of concrete and a tool for mix proportioning. Progresses in the correlation between mix proportioning and rheological parameters would of course result but, moreover, the entire approach to mix proportioning could be improved.

Following the first international workshop organized in this field at CBI (Sweden) in September 2006, researchers from various research teams have realized that the numerical techniques they were using were almost as numerous as the researchers themselves. They decided to create a RILEM technical committee and had their first meeting in September 2007 in Ghent. During this first meeting I had the pleasure and honor to chair, these researchers decided to produce a state of the art report describing the present status regarding computational modeling of the flow of fresh concrete.

This report is divided into five chapters. The first chapter deals with the various physical phenomena involved in flows of fresh cementitious materials. The aim of the second chapter is to give an overview of the work carried out on simulation of flow of cement-based materials using computational fluid dynamics (CFD). This includes governing equations, constitutive equations, analytical and numerical solutions, and examples showing simulations of testing, mixing and castings. The third chapter focuses on the application of Discrete Element Method (DEM) in simulating the flow of fresh concrete. The fourth chapter is an introductory text about numerical errors both in CFD and DEM whereas the fifth and last chapter give some recent examples of numerical simulations developed by various authors in order to simulate the presence of grains or fibers in a non-Newtonian cement matrix.

I would like to finish this introduction by expressing my sincere gratitude to the contributors, without whom this RILEM report will never have been published

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Contents