

Simulation of Fresh Concrete Flow

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Volume 15

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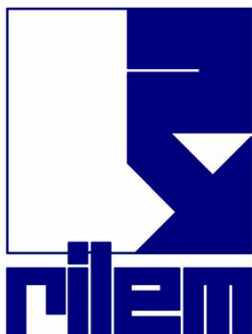
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Introduction

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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

| | |
|---|-----------|
| 1 Physical Phenomena Involved in Flows of Fresh Cementitious Materials | 1 |
| <i>Nicolas Roussel, Annika Gram</i> | |
| 1.1 Introduction..... | 1 |
| 1.2 Is Concrete a Discrete or a Continuum Material? | 2 |
| 1.3 Macroscopic Rheological Behavior | 3 |
| 1.4 Multi-scale Approach..... | 4 |
| 1.5 Particle Interactions..... | 6 |
| 1.5.1 Review of Interactions | 6 |
| 1.5.2 Brownian Forces and Colloidal Interactions at the Cement Paste Scale | 6 |
| 1.5.3 Direct Contact Network between Particles..... | 7 |
| 1.5.4 Hydrodynamic Interactions and Viscosity | 8 |
| 1.5.5 Relative Contributions of Yield Stress and Viscosity and Bingham Number | 10 |
| 1.5.6 Kinetic Energy and Reynolds Number..... | 11 |
| 1.6 Stability and Static Segregation | 12 |
| 1.7 Dynamic Segregation and Granular Blocking..... | 13 |
| 1.8 Fiber Orientation and Induced Anisotropy..... | 16 |
| 1.9 Thixotropy and Transient Behavior | 17 |
| 1.10 Behavior at the Walls | 19 |
| 1.10.1 Slip Velocity and Slip Layer | 19 |
| 1.10.2 Wall Effect | 19 |
| 1.10.3 Wall Roughness and Particles Size | 20 |
| References | 21 |
| 2 Computational Fluid Dynamics | 25 |
| <i>Lars Thrane, Ana Bras, Paul Bakker, Wolfgang Brameshuber, Bogdan Cazacliu, Liberato Ferrara, Dimitri Feys, Mette Geiker, Annika Gram, Steffen Grünewald, Samir Mokeddem, Nicolas Roquet, Nicolas Roussel, Surendra Shah, Nathan Tregger, Stephan Uebachs, Frederick Van Waarde, Jon Elvar Wallevik</i> | |
| 2.1 Introduction to Computational Fluid Dynamics | 25 |
| 2.2 Material Behaviour Law..... | 27 |

| | | |
|----------|---|-----------|
| 2.2.1 | Governing Equations..... | 27 |
| 2.2.2 | Constitutive Equations – Generalised Newtonian Model | 28 |
| 2.3 | Solving a Fluid Problem..... | 29 |
| 2.3.1 | Global Analysis | 29 |
| 2.3.2 | Dimensional Analysis of Concrete Flows | 30 |
| 2.3.2.1 | Dimensional Analysis of Slump and Slump Flow Tests | 30 |
| 2.3.2.2 | Standard Shear Flows in Industrial Practice..... | 31 |
| 2.3.2.3 | Filling Prediction..... | 32 |
| 2.4 | Analytical Solutions | 33 |
| 2.4.1 | Free Surface Flow | 33 |
| 2.4.1.1 | Slump and Slump Flow | 33 |
| 2.4.1.2 | Channel Flow | 35 |
| 2.4.2 | Confined Flow..... | 37 |
| 2.5 | Numerical Solution | 39 |
| 2.6 | Simulation of Fresh Cementitious Materials | 41 |
| 2.6.1 | Standard Test Methods..... | 41 |
| 2.6.2 | Viscometers..... | 44 |
| 2.6.3 | Mixing | 45 |
| 2.6.4 | Casting | 48 |
| 2.6.4.1 | SCC Wall Casting | 49 |
| 2.6.4.2 | Castings – Consequences of Structural Build Up..... | 51 |
| 2.6.5 | Industrial Applications | 53 |
| 2.6.5.1 | Prediction of Flow in Pre-cambered Composite Beam | 53 |
| 2.6.5.2 | Flow Simulation of Fresh Concrete under a Slip-Form Machine | 54 |
| 2.6.5.3 | Flow Simulation of Nuclear Waste Disposal Filling | 57 |
| | References | 59 |
| 3 | Simulation of Fresh Concrete Flow Using Discrete Element Method (DEM)..... | 65 |
| | <i>Viktor Mechtcherine, Annika Gram, Knut Krenzer, Jörg-Henry Schwabe, Claudia Bellmann, Sergiy Shyshko</i> | |
| 3.1 | Introduction..... | 65 |
| 3.2 | Discrete Element Method..... | 67 |
| 3.2.1 | Governing Equations..... | 67 |
| 3.2.2 | Solution Procedure | 68 |
| 3.2.3 | Software Used in Concrete Engineering | 69 |
| 3.2.3.1 | Particle Flow Code (PFC) from ITASCA | 69 |
| 3.2.3.2 | EDEM from DEM Solutions..... | 70 |

| | | |
|----------|--|-----------|
| 3.2.3.3 | Alternative DEM Software..... | 71 |
| 3.3 | Simulating Concrete Flow Using DEM | 72 |
| 3.3.1 | Discretisation of Concrete by Discrete Particles | 72 |
| 3.3.2 | Rheological Model | 73 |
| 3.3.3 | Constitutive Relationships..... | 75 |
| 3.3.4 | Parameter Estimation | 76 |
| 3.3.5 | Particle Size Effect and Dimensional Analysis | 80 |
| 3.4 | Calibration and Verification..... | 82 |
| 3.4.1 | Slump and Slump Flow | 82 |
| 3.4.2 | J-Ring Test and L-Box Test | 86 |
| 3.4.2.1 | J-Ring Test..... | 86 |
| 3.4.2.2 | LBox Test..... | 87 |
| 3.4.3 | Funnel Flow | 88 |
| 3.4.4 | Casting | 89 |
| 3.5 | Industrial Applications | 90 |
| 3.5.1 | Mixing | 90 |
| 3.5.2 | Filling | 91 |
| 3.5.3 | Extrusion | 93 |
| 3.6 | Future Perspectives | 94 |
| 3.7 | Summary | 96 |
| | References | 96 |
| 4 | Numerical Errors in CFD and DEM Modeling | 99 |
| | <i>Jon Elvar Wallevik, Knut Krenzer, Jörg-Henry Schwabe</i> | |
| 4.1 | Introduction..... | 99 |
| 4.2 | Basics of CFD – Understanding the Source of Errors..... | 100 |
| 4.2.1 | Taylor Approximation..... | 101 |
| 4.2.2 | A Very Simple CFD Example – Automatic Generation of Errors..... | 103 |
| 4.3 | Numerical Errors (E1)..... | 106 |
| 4.3.1 | Discretization Error | 106 |
| 4.3.2 | Iterative Convergence Errors..... | 109 |
| 4.3.3 | Round Off Errors..... | 111 |
| 4.4 | Coding Errors (E2)..... | 112 |
| 4.5 | User Error (E3)..... | 112 |
| 4.6 | Error from Input Uncertainties (U1) | 113 |
| 4.7 | Physical Model Uncertainty (U2) | 114 |
| 4.7.1 | Choosing the Correct Material Model..... | 114 |
| 4.7.2 | Implementation of Yield Stress | 114 |
| 4.7.2.1 | A Theoretically Correct Bingham Presentation ... | 114 |
| 4.7.2.2 | Viscoplastic Implementation for CFD | 115 |
| 4.7.2.3 | Comparison of Different Viscoplastic Implementations..... | 117 |

| | | |
|----------|--|------------|
| 4.8 | Sources of Numerical Error in DEM Simulations..... | 120 |
| 4.8.1 | Mono-disperse Particles | 120 |
| 4.8.2 | Time Step Errors | 120 |
| 4.8.3 | Density Scaling Errors | 121 |
| 4.8.4 | Calibration Errors..... | 122 |
| 4.8.5 | Particle Size..... | 122 |
| 4.8.6 | Particle Shape..... | 123 |
| | References | 123 |
| 5 | Advanced Methods and Future Perspectives..... | 125 |
| | <i>Ksenija Vasilic, Mette Geiker, Jesper Hattel, Laetitia Martinie,</i> | |
| | <i>Nicos Martyts, Nicolas Roussel, Jon Spangenberg</i> | |
| 5.1 | Introduction..... | 125 |
| 5.2 | Case Studies | 126 |
| 5.2.1 | FEMLIP Method from EC Nantes | 126 |
| 5.2.2 | Two-Phase Model from IBAC and IVT..... | 127 |
| 5.2.3 | Dissipative Particle Dynamics from NIST | 130 |
| 5.2.3.1 | Concrete as a Multi-scale Material..... | 130 |
| 5.2.3.2 | Computational Models | 131 |
| 5.2.3.3 | Some Fundamental Insights into Yield Stress..... | 133 |
| 5.2.3.4 | Insights to the Effect of Particle Sizes and Shapes..... | 135 |
| 5.2.4 | Prediction of Dynamic Segregation from DTU..... | 137 |
| 5.2.5 | Fibre Orientation Modelling..... | 137 |
| 5.2.5.1 | Industrial Flow | 137 |
| 5.2.5.2 | Background | 138 |
| 5.2.5.3 | Aligned Fibre Assumption | 138 |
| 5.2.5.4 | Interactions between Fibres..... | 139 |
| 5.2.5.5 | Yield Stress Effect..... | 139 |
| 5.2.5.6 | Multi-fibres Approach..... | 139 |
| 5.2.5.7 | Application to Shear Flow between Two Parallel Walls | 140 |
| 5.2.5.8 | Industrial Application..... | 140 |
| 5.2.6 | Fully Coupled Simulation of Suspension of non-Newtonian Fluid and Rigid Particles | 142 |
| 5.2.6.1 | Modelling Strategy..... | 142 |
| 5.2.6.2 | Level of Fluid: Fluid Dynamics Solver | 142 |
| 5.2.6.3 | Level of Fluid: Free Surface Algorithm | 142 |
| 5.2.6.4 | Level of Fluid-Particles Interaction: Immersed Boundary Method..... | 143 |
| 5.2.6.5 | Level of Particles: Adaptive Sub-stepping Algorithm | 143 |
| 5.2.6.6 | Level of Particles: Interaction of Particles | 143 |

| | |
|--|------------|
| Contents | XIX |
| 5.2.6.7 Application to the Effect of Particles on Effective Rheological Properties | 144 |
| 5.2.6.8 Application to Dynamic Segregation in a Complex Flow | 144 |
| References | 145 |
| Author Index | 147 |