24th Conference and Workshop on Rheology of Building Materials

Ostbayerische Technische Hochschule (OTH) Regensburg, Germany
March 11 – 12, 2015

After 24 years the meeting on Rheological Measurements of Building Materials has become a well established, international event. On March 11, around 130 guests and speakers from 16 different countries gathered again in Regensburg. The presentations covered several fields of new rheometers and measuring procedures for controlling the workability of fresh concrete and other mineral materials. Concrete, self-compacting concrete, eco-concrete, cementitious foams, strain-hardening cement composites and piles of sand were part of the presentations.

The lecture series was opened with a welcome address by Markus Greim, CEO of Schleibinger Geräte, by OTH President Wolfgang Baier, and by OTH Professor Wolfgang Kusterle. Rudolf Röck, University Innsbruck, presented a novel experimental method for the determination of rheological parameters of green concrete with a sphere-based viscometer. Hereby, a steel sphere is drawn vertically through the material with constant velocity while the stationary drag value is monitored. Rerunning the experiment at different velocities gives access to drag vs. velocity and shear stress vs. shear rate relation, respectively. In contrast to commonly used rotational viscometers, the developed method can be applied while concrete is vibrated. Based on the conducted experiments, there is a drastic change of rheological behavior when concrete is vibrated. While the non-vibrated fluid essentially shows Bingham-type behavior, the vibrated fluid is characterized by shear thinning. At very low velocities structural interruptions were observed with one or two local maxima in the drag vs. velocity relation. These bumps cannot be modeled by commonly employed constitutive laws for non-Newtonian fluids. Based on the obtained data for various concretes characterized by different consistencies and composition, material parameter in scope of the description as a power-law fluid were back-calculated.

The relevance of thixotropy and structural build-up on the workability of concrete was the topic of Dirk Lowke, TU Munich. His presentation showed that, in addition to robustness, in particular thixotropy is decisive for the assessment of segregation resistance of self-compacting concrete (SCC). Both of these rheological parameters were linked qualitatively and quantitatively by model with the interparticle interactions in the fresh binder paste. Based on modelling the interparticle interactions and the results of the rheological investigations of the mortar phase, it was possible to identify the water/solid ratio, the maximum packing density and superplasticizer adsorption as the main factors governing thixotropy and robustness and therefore segregation resistance. Moreover, it was shown that SCC with an optimized binder paste composition is able to possess a high segregation resistance to variations in water content of up to 20 l/m³.

Egero Secrieru, TU Dresden, was discussing a model for the pumpability prediction of Strain-Hardening Cement Based Composites (SHCC) at various temperatures using experimental methods. He presented the results of an investigation aimed to evaluate the rheological behavior of fresh SHCCs with and without superabsorbent polymers (SAP) under the coupled influence of time and temperature. The effect of temperature variation on the fresh properties SHCC was examined in terms of rheology, tribology and pumpability for up to 60 minutes after mixing. The flow behavior of SHCC was approximated to that of Bingham fluid, characterized by yield stress and plastic viscosity. Furthermore, two methods to predict the mixture pumpability, tribometer and Sliding Pipe Rheometer (SLIPER), were highlighted and compared.

Non-destructive methods of imaging of concrete structure and rheological processes presented Szymon Korzekwa, University Gliwice, He discussed nuclear magnetic resonance and X-ray microtomography as tools to track rheological processes, processes of hydration and tracing damage in the specimen. NMR allows 3D imaging, as well as spectroscopy. Neutron activation analysis (NAA) is one of the most precise non-destructive methods for determining the concentrations of elements in any kind of materials. It is extremely interesting to use that method to identify trace or rare earth elements in building materials. The method is based on nuclei activation as a result of the collision with neutron and therefore requires a very efficient source of neutrons like nuclear reactors.

Similar techniques used Ralf Seemann, University Saarbrücken, for his elementary studies about the wet granular pile stability. When mixed with a certain amount of water, a pile of dry sand turns into a moldable

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material. The surface tension of the liquid spanning the grains results in a considerable stiffness of the granulate. The geometry of the liquid interfaces in such a random arrangement of grains is of extraordinary complexity and depends strongly on the liquid content. Surprisingly, the mechanical properties of granulates are largely independent of the liquid amount over a wide range. This puzzle was solved with the help of X-ray microtomography and subsequent statistical analysis of the liquid distribution and grain packing geometry. The results show that the remarkable insensitivity of the mechanical properties to the liquid content is due to the particular organization of the liquid in the pile into open structures. For spherical grains, a simple geometric rule was established, which relates the macroscopic properties to the internal liquid morphologies. He presented evidence that this concept is also valid for systems with non-spherical grains.

Marble powder is abundantly available in various parts of the world, as there is a great demand of marble stones. The particle size of these material are marginally courser compared to cement and fly ash. Detailed experimental studies by Supratic Gupta, IIT Delhi, have shown that with proper water correction, strength is not compromised. Results of his experimental study show the possibility of use of marble powder in SCC, in comparison to fly ash based and sand based SCC mixes. Here, flow, T500, V funnel time and viscosity by BT2 Rheometer have been presented. It clearly shows that marble powder can be successfully used in SCC.

Very lightweight mineralized foams have an enormous potential as a non-combustible insulation material due to its low thermal conductivity and its structural bearing capacity. In its fresh form, mineral foam consists of a continuous liquid cementitious phase and a dispersed gaseous phase. In this stage, the mineral foam is a metastable material, at least from a macroscopic perspective. The collapse of a foams inner cellular structure caused by different superimposed impacts, start already right after its formation. In general, the viscosity of a cementitious continuous phase and the surfactant might stabilize this process. To better understand the effect of gas dispersion on the rheological behavior of the continuous cementitious phase of mineral foams, an extended study has been carried out by Albrecht Gilka-Bötzow, TU Darmstadt. Various experiments on the viscosity, minimal yield stress, stress hysteresis and structural viscosity were conducted. Furthermore, photogrammetry and mercury intrusion porosimetry have been done to determine the porosity of the mineralized foams for different binder paste rheologies and to identify different classes of foam types. Slightly scattered results were observed for the various types of binders regarding their viscosity and their minimum yield stress.

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Beside this, significantly different viscosities were observed at low stress levels between a colloidal and a so called high performance mixing system. The mix prepared with a colloidal system showed a higher viscosity at low shear rates but also a sharper drop in viscosity at higher rates. Probably most interesting result appeared after evaluating the rheological parameters of the minimized foams from a porosity class point of view. It turned out that a significant difference in terms of viscosity and minimum flow could be identified.

The effect of PCE superplasticizers (SP) on powders for eco-concrete was the topic of Joachim Juhart, TU Graz. By investigations of spread flow and Rheometer tests he showed that the SP-demand of CEM I is greater than the SP-demand of most stone powders with similar fineness to ordinary Portland cement, but differs for quartz-dolomite-limestone. Furthermore the SP-demand increases with the fineness of the powders. An estimation of spread flow of powder-mixes is possible, if the SP demand of the single ingredients is known, by summing up the weighted spread flows. As an outlook Juhart recommended the testing of the effect of SP on powders in pore solution of cement paste.

Cement based materials have become more complex during the last decades. The relatively simple system, consisting of cement water and aggregates, has been amended by admixtures and additions. As a result modern concrete systems have become more complex regarding to the design and handling. Therefore the robustness of the rheology is a serious matter of concern. In order to provide the customer with reliable products the use of a well working quality control system is required. So called cusum (cumulative sum) charts are very efficient in detecting small systematic changes in a process. Cusum observes the cumulative curve of the deviations from the targeted value. In the production of self-compacting concrete two performance deviances are thinkable, either segregation or stagnation, which can be counteracted by either the addition of stabilizing agents or the addition of supplementary superplasticizer, respectively. The presentation of Wolfram Schmidt, BAM Berlin, showed how the cusum chart in combination with the mentioned corrective measures can help optimizing the fresh concrete production of SCC, so that target values can be achieved with low standard deviations, regardless of scattering qualities of the concrete constituents.

After the conference at March, 11, like every year things were furthermore discussed in the evening, at a typical restaurant located in the historical city of Regensburg. With more than 40 participants the workshop for rheological measurements on March, 12 also was well attended. In the concrete lab Ivan Paric, OTH Regensburg, mixed a 50 l batch of self-compacting concrete. The properties of this material were measured with the inline mixer-rheometer called RheoCT and the construction site concrete rheometer eBT2. In a next step, the pumpability of this concrete was predicted with a new developed sliding pipe rheometer (SLIPER).

The 25th Regensburg colloquium and workshop will take place March 2016 at the OTH Regensburg. Most of the presentations are available online at http://www.schleibinger.com/k2015.html

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Figure 1: Participants during the seminar at Regensburg, Germany.

Figure 2: Workshop for rheological measurements at the concrete lab of Ivan Paric.

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