14[TH] Conference and Workshop "Rheological Measurement of Building Materials"

9.-10.3.2005
Regensburg, Germany

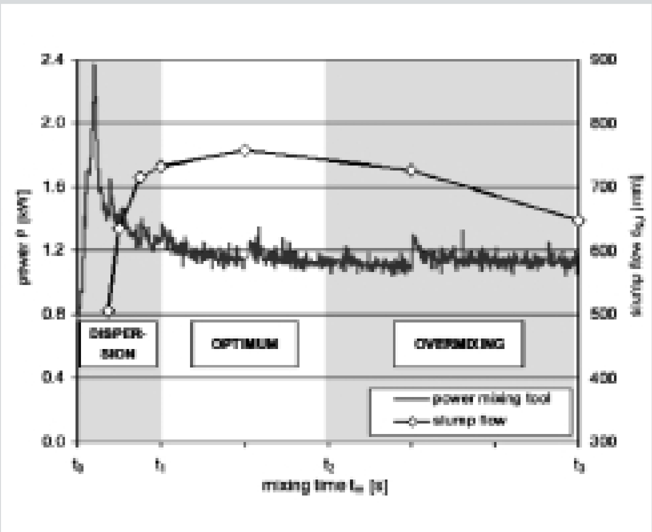
The 14[th] Conference and Workshop on "Rheology of Building Materials" was held in Regensburg in March 2005. As host, Prof. Kusterle welcomed about 100 participants to the the University of Applied Science. Over the last few years this conference has become an important meeting for the European research community and for the application engineers from the construction materials industries and building industries and therefore several topics were discussed in detail:

Along the strength and durability, the workability is an important property of mineral based materials like concrete, mortar, plaster etc. Up to now, this property is often still estimated or determined in a very heuristic way with spread tables or slump cones. In the last few years the development of new additives like stabilizers and superplasticizers has led to new construction materials like ultra-high-strength concrete or self compacting concrete. For these new materials formulation design and an understanding of the rheological properties for material handlingand transportation is needed. This development is shown in the topics of the papers presented in Regensburg. They can be coarsely divided into three groups: the rheological effects of additives and admixtures, self compacting concrete (SCC), and measurement technolgy. Building materials like cement paste, mortar, or tile adhesive are, unfortunately, not only non-Newtonian but also dependent on time and shear-history. This property was in the focus of S. Lowke, TU Munich, Germany, in his contribution about: "Mixing self compacting concrete". While numerous publications of rules and guidelines are available for the composition and properties of concrete and its raw materials, the actual process of concrete producing is largely left to the user. However rheological properties are significantly influenced by the mixing procedure. The raw materials are to be mixed in such a way during mixing that the mixture appears to be uniform. As a matter of principle, the mixing duration is to be selected in such a way that sufficient mixing of the raw materials takes place. It is important that water and superplasticizer are evenly distributed and sufficiently disintegrated. If the mixing energy is insufficient, the best properties for a given formulation will not be achieved. The necessary mixing duration depends mainly on the mixer design, as well as the mixture proportion. Due to the low water contents relative to the powder contents and high additive dosages, more energy is required for the production of selfcompacting concrete to distribute the raw materials evenly. A mixing time of 240 s for a self compacting concrete (compared to 30 to 60 s for a standard concrete) is not uncommon in a ready-mix concrete plant.

First investigations at the Munich TU revealed a large potential to optimize this process. An intensive mixer of the machine factory Gustav Eirich with controllable tool velocity was made available to cbm for these examinations. It was also possible, to record the power input at the mixing tool and plate during the entire process. Initially, the influence of mixing time t_m, intensity, and proportion of the concrete on the initial consistency, as well as the transient development of the fresh concrete properties of self-compacting concretes were systematically investigated (Fig. 1). Based on these results, the mixing procedure could be optimised and the mixing time significantly reduced. It was possible, by increasing the mixing tool velocity, to reduce the mixing time to 60 s, including time for water and superplasticizer addition. Because to this, the mixing time for the production of self-compacting concretes lies in the range of common vibrating concrete. Production efficiency is improved by speeding up mixing, and, consequently, the production costs for self-compacting concrete can eventually be reduced.

S. Uebachs, RWTH Aachen, Germany, also presented on the topic of self compacting concrete

Figure 1: Effect of mixing time.



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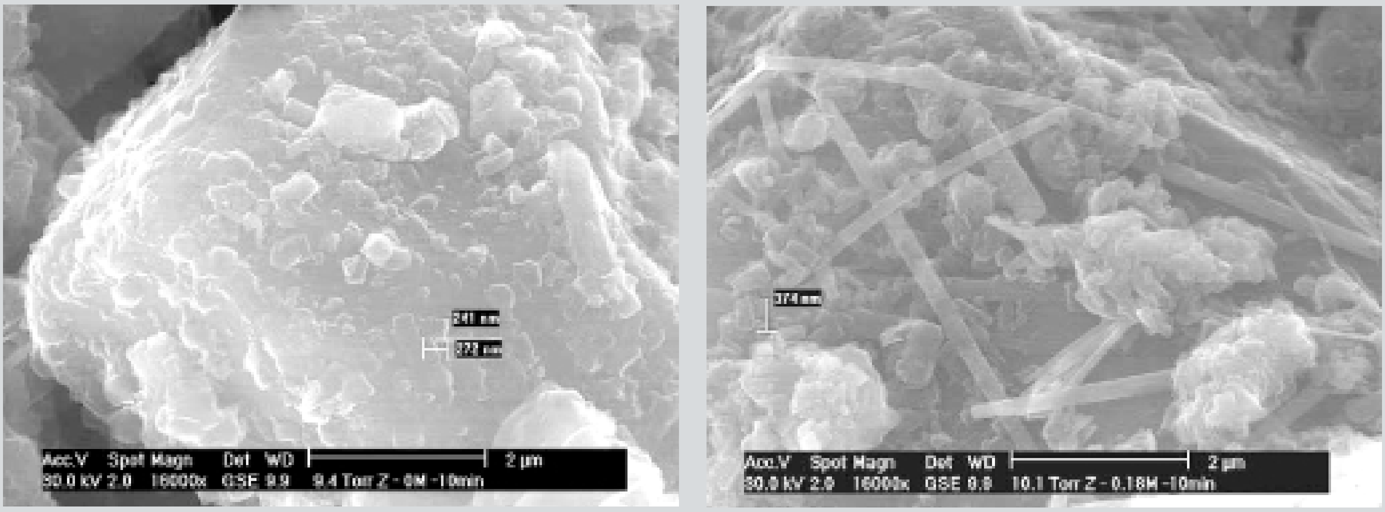

Figure 2: Reference specimen (left) and 0.18% K_2SO_4 (right).

with "Numerical Simulation if the Flow Beahviour of Self-Compacting-Concrete". For a numerical modeling of the flow process of self-compacting mortars and a Newtonian fluid with comparable viscosity, investigations were conducted using fluid mechanical approaches. The numerical modeling was conducted using the L-Box test. The L-box is formed like a leg filled with concrete and a removable gate is used to keep concrete in the vertical part before starting the test.

To validate the results of the calculation, experiments with the L-Box were carried out. These tests were evaluated using video recordings. It became obvious that the experiment delivered well reproducible results and that the chosen test setup and the evaluation by means of a special software were very well suited. The flow curves of the SCC mortar were determined by means of the Viskomat NT. The rheological characteristic values of the Newtonian fluid were determined with a coaxial cylinder viscometer. The results showed that the properties of the Newtonian fluid are very similar to those of the mortar. Despite having a comparable viscosity, both fluids display significantly different flow velocities in the L-Box. The flow velocity of a fluid is thus not determined by the viscosity alone. The numerical modeling with a commercial CFD-Code yielded good results for the Newtonian fluid. With modifications, the flow process of the self-compacting mortar can be also simulated. The next step will now be the expansion of the model by including an additional phase, the coarse aggregate, in order to simulate the flowing behavior of self-compacting concretes.

SELF COMPACTING CONCRETE REQUIRES MODERN SUPERPLASTICIZERS (SPS)

Hana Kucerová, Technical University Brno, Czech Republic (in cooperation with the University Weimar, Germany) talked about the influence of K_2SO_4 in the rheological properties of cement paste with superplasticizers. The workability loss of cement paste containing SP due to the alkali-sulfates is often described only by the adsorption of the SPs on the the surface of the cement particles. The research project was realised with one Cement (CEM I 52,5R), four different K_2SO_4 concentrations betwen 0 and 0.29 mol/l and three SPs. Two based on polycarboxylate esters (PCE), and one on naphthalene sulfonate condensates (NSF). The water/cement ratio was 0.39, the PC dosage 1.5%. The adsorption of the PC was measured with the TOC analysis of the pore-solution, the syngenite and C_3A content by the X-ray diffraction analysis. Figure 2 shows the different structures in the cement paste with and without K_2SO_4, scanned with an environmental scanning electron microscope. In the right picture the needle-like syngenite crystals can be seen.

In accordance to the rheological measurements with the Viskomat NT it could be shown, that the workability loss of cement paste with K_2SO_4 is mostly based on the growth of syngenite. The extent of syngenite growth, is influenced by the SPs. In a second step the influence of Na_2SO_4 was also tested. It could be shown that with an concentration of 0.29 mol/l a higher shear resistance occurs, which is based on the higher etringitte generation.

Not only plasticizers, but also thickening agents are important for the rheological properties of modern building materials. Andrea Glatthor, consultant for building materials, Stadtoldendorf, Germany, gave a report entitled "Starch ethers as a rheological additive for dry mortars." Starch ethers are an important additive for dry mortars, like plaster or tile adhesives. As a flocculant, they adsorb at the same time at two particles, creating a network structure in the suspension. The yield value of the mortar increases. Two types of starch ethers may be distinguished, independent of the binder: type 1 is already effec-

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tive at a very low dosages (< 0.01% of the cement mass), but over a certain content level the material will re-disperse again. Type 2 needs a higher initial dosage, but the power increases with the amount of additive. With a higher Ca^{2+} concentration some of 15 tested products are loosing their thickening power. This may be a problem when they are used with a cement based binder, and the Ca^{2+} concentration in the cement is not constant. The activity of the starch ether is also influenced by the pH-value, which is important for example in combination with plaster of Paris.

So starch ethers are a powerfull additive for controlling the rheological properties of dry mortars. But it is necessary to test several binders, additives and dosage combinations to find the best fitting product. O. Wallevik, IBRI Reykjavik, Iceland, presented a study of "Some aspects of Rheology of Cement Suspension containing Silica Fume". Silica fume (SF) is a byproduct of producing silicon metal or ferrosilicon alloys. SF consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO_2 content, SF is a very reactive pozzolan when used in concrete, and may replace a part of the cement content. Concrete containing SF can have very high strength, and a low permeability for water, air, and chloride. On the other side the high surface area enforces plastic shrinkage. From the rheological point of view, SF lowers the viscosity of fresh concrete, increases the yield value, and adds some thixotropic effects. So SF may work as a stabilizer in self compacting concrete which prevents sedimentation, as a sticking agent in a shotcrete, or as a pumping agent.

The last lesson was not about the tested materials, but the measurement technology itself. M. Greim, Schleibinger Geräte, Buchbach, Germany gave a survey about the measurement technology for rheological properties of paste, mortar and fresh concrete. The known systemes may be divided into four categories: Gravity driven systems like the slump cone and the spread table. Mixing systems like the Tattersal rheometer or the Viskomat. Modified standard systems like the BML rheometer where cylinder, or cone-plate systems, are specially adopted. Finally systems exist, where specially formed probes, like balls or cylinders, are moved through the material, measuring force and speed. Most of the over 20 presented systems, are a combination of the four basic working principles. Generally a rheometer for building materials has to avoid sedimentation and segregation. The influence in the material by motion has to be as small as possible. Due to the time dependence of the material properties, the measurement time has to be as fast as possible.

After the colloquium on March 9th, as every year, further discussion took place in the evening at a typical restaurant located the historical city of Regensburg. On March, 10th some basic principles of rheology of building materials were demonstrated in a practical way during the laboratory workshop. First the basics of rheology were shown by some simple but impressive experiments. Using a cement based mortar the handling of building materials with a rheometer was demonstarted.

The 15th Regensburg colloquium and workshop will take place in mid-March 2006 at the FH Regensburg. Most of the 2005 papers are presented in full at http://www.schleibinger.com/k2005/regen05US.html.

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