Rheological behavior of the continuous phase of foams and its effect on the dispersed phase

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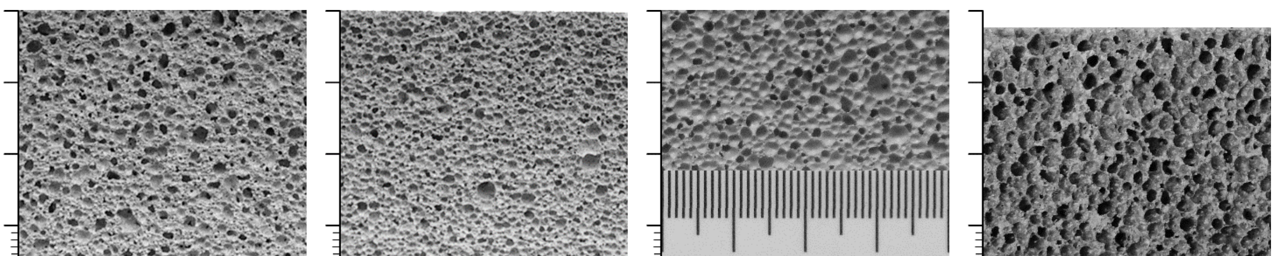
Introduction

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 any case the precondition for a successful application is a reliable production technique. Also nowadays in precast fabrication of very lightweight mineralized foams with defined properties, there is lack of robust production methods. Main obstacles are the sensitivity of fresh mortar towards their contact with water absorbing materials and their limited temporal persistence during the fresh phase.

In its fresh form, mineral foam consists of a continuous fluidable 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. Collapsing of a foam means that the dispersed gas is separating from the fluid phase [1, 2]. In the case of foams with a high content of dispersed gas it means that large instable bubbles are formed or that these bubbles collapse causing local instabilities. In general, the viscosity of a cementitious continuous phase and the surfactant might stabilize this process.

Material and Methods

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 at the Fachgebiet Werkstoffe im Bauwesen of TU Darmstadt. Various experiments on the viscosity, minimal yield stress, stress hysteresis and structural viscosity were conducted, following the DIN SPEC 91143-2 guidelines [3]. 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 (Figure 1). In a first approach the binder consistency was varied only by changing the water to cement ratio while all other inherent and external factors where kept constant. The studies were carried out by three different groups of persons and two types of slurry mixers.



Pore structure type A *Pore structure type B* *Pore structure type C* *Pore structure type D*

Figure 1: porosity classes of foams

Results

Slightly scattered results were observed for the various types of binders regarding their viscosity (Figure 2) and their minimum yield stress. In addition to this, there were some other typical findings as well. In particular with respect to the distribution of results towards the type of binder paste and their associated viscosity and flow-ability, some noticeable observations could be made. In the first place, changing the personnel that carried out the tests didn't had any significant effect on the results. Beside this, a significantly different viscosities were observed at low stress levels between a colloidal and a so called “high performance” mixing system. The colloidal system showed a higher viscosity at low shear rates but also a sharper drop in viscosity at higher rates. The rheology mixing experiments also showed a higher intrinsic viscosity for the binder pastes mixed by a high performance mixer. These results showed a higher probability for receiving a homogenous mixing quality when using a colloidal mixing system.

Probably most interesting result appeared after evaluating the rheological parameters of the minimalized 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. Similar results could also be observed whenever dividing the curves by water-cement ratio (Figure 2). Moreover, colloidal mixing systems produced in a more stable and reliable mineral foam with a fine and homogeneously distributed porosity.

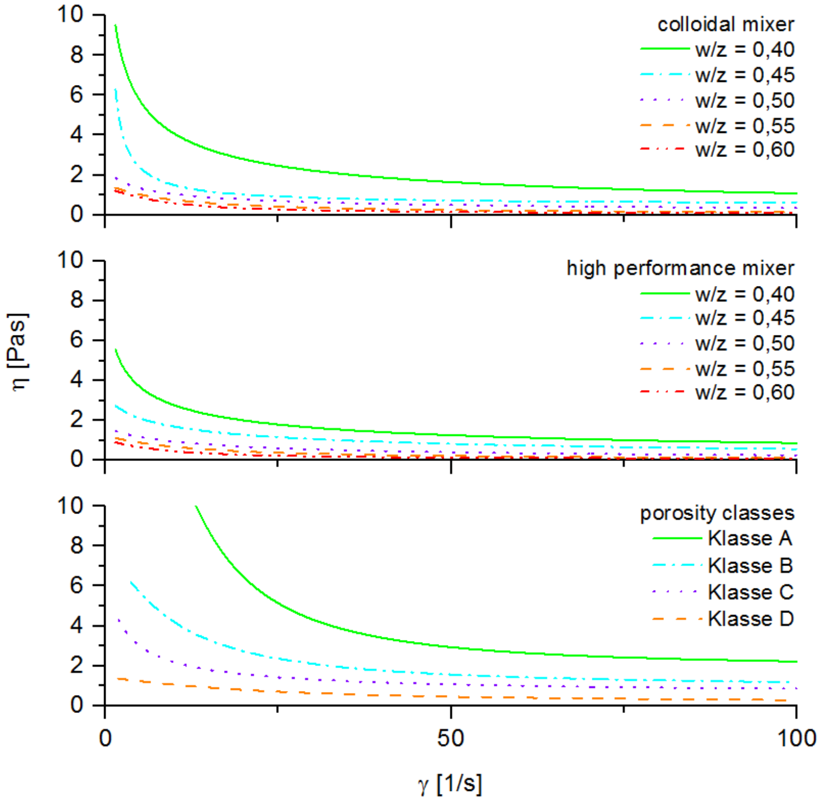


Figure 2: Viscosity versus shear rate for different mixing systems, water to cement ratios and porosity classes.

Discussion

Experiments carried out in this study showed that investigations on the rheological behavior of the continuous cementitious phase are very useful to evaluate their suitability and robustness for the production of mineral foams. With this it becomes possible to develop and characterize new compositions of cementitious materials for the continuous phase of foams. Testing local materials or alternative binders can be assessed in a more efficient way. Based on these findings for the ETA-Factory research project at the TU Darmstadt a foam generator was constructed which uses a colloidal premixing system and water-cement ratios that ranges between 0,4 and 0,43 leading to a very stable and robust production of mineral foams in real full scale situations [4].

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