Shear-induced particle migration in a cement slurry under pipe flow

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The behavior of a suspension made of white cement slurry and 0.3 vol. fraction (ϕ_0) red glass beads is studied under pipe flow. Three flow distances, imposed by large amplitude oscillations[1,2], are investigated: 25 m, 48 m and 200 m, below and above the development length predicted for a Newtonian suspension of identical bead size and pipe diameter[3]. An extensive rheological characterization is performed and shows that the suspension behaves as a yield stress, shear thinning, thixotropic fluid.

The radial distribution of beads over the pipe cross-section is measured after the hardening of the cement and shows a concentration gradient. Averaging all results, an increase in bead concentration by 35 % above the nominal concentration (reaching an average $\phi = 0.41$) is measured in the pipe center region, and a decrease by 20 % (reaching an average $\phi = 0.24$) near the pipe wall. The absence of further densification of beads in the pipe center contrasts with results obtained in Newtonian fluids[4,5,6]. This is attributed to the paste increase in yield stress with time, predicted to result in a plug flow zone of increasing radius with time.

This work shows that the radial migration of particles in cement slurries may occur beyond the formation of a lubricating layer near the wall, discussed in literature, and over the whole cross-section of the pipe. This phenomenon may contribute to the formation of plugs (zone of high concentration of aggregates) at the forefront of concrete during pumping, explaining blockage.

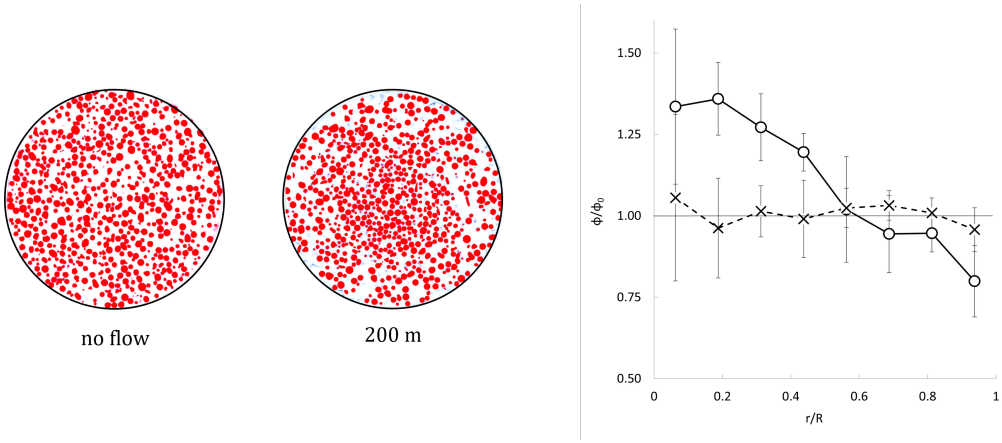

Figure 1: *Left*: Representative cross-sections of cut and polished hardened cement samples. *Right*: Average normalized concentration profile of beads plotted as a function of normalized radial position: reference (×) and flow samples (○).

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