How chemistry influences the stiffness of fresh cement paste

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Abstract

When cement powder is mixed with water, attractive interactions between the cement grains result in the formation of a flocculated network. This network can withstand loads, and is at the origin of the macroscopic stiffness of fresh cement paste. Over time, the stiffness of the paste increases due to the chemical formation of hydration products that strengthen the flocculated network. High quality time-resolved stiffness data can be obtained with oscillatory shear measurements. However, such measurements do not directly capture the chemical reactions at the origin of the formation of hydration products. Thus, time-resolved rheology data only offer limited insights regarding the origin of stiffness increase in fresh cement paste. In this work, we perform oscillatory shear and isothermal calorimetry measurements to couple the chemical formation of hydration products with the stiffness evolution. Over our experimental window, we obtain a single exponential evolution of stiffness with heat of hydration, allowing to decouple the effects of chemical kinetics from the evolution of mechanical properties. We obtain evidence supporting that the stiffness evolution is governed by a strengthening of grain-to-grain contacts in the network, due to the formation of hydration products on the surface of the grains. We show that time-resolved rheology data is easily biased by different hydration kinetics across samples, which has led to a number of contradictory statements in the literature.

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