STRESS ANISOTROPY INDUCED BY THE MEMORY EFFECT OF DRYING PASTE

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Mud crack patterns familiar in everyday life have isotropic cell structures, but applying horizontal oscillation for a short time before drying makes laminar crack patterns perpendicular to the shaking direction after dying in a uniform layer of paste-like mixture of fine granular materials and liquid, such as clay paste. This *memory effect of shaking* is known to occur in paste with plasticity when stresses larger than the yield stress are applied initially[1, 2]. A few phenomenological continuum theories propose mechanisms of initial shaking to make anisotropic residual stresses[3, 4]. However it had been difficult to detect the anisotropy experimentally before emergence of a crack pattern. Recently we used a soft container with a thin sheet of elastic bottom for drying experiments of paste and found that the elastic sheet bended along the direction of initial oscillation as the paste layer shrank with drying. Horizontal stresses in the bending direction can be estimated from the curvature of the elastic sheet. In this research, stresses developing in a uniform layer of drying paste were measured in this method.

We made a special container which has 4 flat stainless springs as parts of the flat bottom and measured the vertical displacements with 4 laser sensors. As each spring is allowed to bend only in one direction, stresses parallel and perpendicular to the initial oscillation direction can be estimated from the displacements of the two springs labeled A and the other two springs labeled B in the photograph of Fig. 1, respectively. We investigated development of stresses in a drying process of a mixture of Calcium carbonate ($CaCO_3$) powder and water while monitoring its solid volume fraction, which was determined from the weight of paste.

The experimental results confirmed that stresses in $CaCO_3$ paste develop up to the order of $20 - 40$kPa for cracking and a little anisotropy between A and B was found before cracking. The stress difference A-B is positive before cracking, that is, stresses parallel to the initial oscillation is larger than stresses perpendicular to the initial oscillation. Although A-B is at most several kPa, the magnitude increases significantly with drying in comparison with the yield stress of initial paste, which is known to be less than 10Pa [1]. Mechanical responses of paste were also investigated with bending tests in the middle stage of a drying process. The results indicate that $CaCO_3$ paste layers behave as a typical plastic material even just before cracking and suggest that drying process develops initial weak anisotropy significantly with accompanying plastic deformation to make a preferential crack direction.

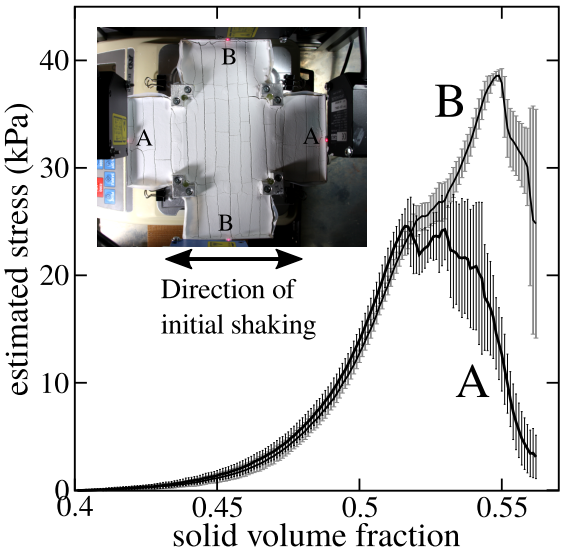

Figure 1. Stresses in a paste layer increase as the solid volume fraction increases with drying. A and B indicate the average stresses in the direction parallel and perpendicular to initial shaking. Their maximum values correspond to the first appearances of perpendicular and parallel cracks, respectively.

References

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