Geophysical Research Abstracts
Vol. 14, EGU2012-14462, 2012
EGU General Assembly 2012

Evolution and failure of liquid bridges between grains due to evaporation and due to extension

T. Hueckel (2), B. Mielniczuk (1), and M. Said El Youssoufi (1)

(1) Laboratoire de Méchanique et Génie Civil UMR UM2-CNRS 5508, Université Montpellier 2, 34095 Montpellier Cedex 5, France, (2) Duke University, Durham, NC 27708, USA

Evolution and rupture of liquid bridges between glass spheres during liquid evaporation and during mechanical extension was examined. The latter type of the tests has been widely studied, while a number of pertinent measurements during transient evaporation have not yet been reported. Also the resultant total capillary forces were measured and geometrical characteristics (curvature radii)were recorded with a photo camera and high-speed camera and subsequently digitalized.

The obtained results reveal substantial differences in geometry of liquid bridges during extension and evaporation. On the other hand, evaporation and extension of liquid bridgelead to a similar qualitative response in terms of the pressure within the liquid bridge, starting with a significant suction, which initially somewhat increases during evaporation to reach a maximum, followed by a rapid monotonic decrease until zero, to become a sizable positive pressure prior to rupture. Extension same pattern is followed, except that there is no initial suction increase. Hence, in both cases, rupture consistently occurs at a positive fluid pressure.

The pressure evolution is a simple resultant of the evolution of radii of curvature, with the neck radius becoming smaller than meridian radius.

In terms of resultant capillary force, as the area of the bridge cross-section decreases with the square of the neck radius, the pressure difference is almost entirely negative, in part also due to surface tension component. Nevertheless, the suction decreases nearly monotonically during both processes. Rupture during evaporation of the bridges occurs most abruptly for larger separations, as early as after 25% volume evaporated. It is seen as a bifurcation of the geometry of equilibrium, as demonstrated on a movie with 27, 000 shots per second.

The evolution of a bridge between three spheres exhibits a centrally located thin film instability with a circular hole growing within 1/3000th of a second.

All these findings have an enormous impact on the mechanics of unsaturated media, as they determine the conditions and criteria for the loss of the “sand-castle” cohesion effect in the final phase of soil drying.