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Effect of water on granular matter mechanics, macroscopic scale: Collapse of granular media during wetting.

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Abstract

In soil mechanics, it is well known that the behaviour of the granular soils, as the sand, in the dry state is similar to the saturated state. Between these two extremes states exist various domains of water content often named: hygroscopic, pendular and funicular.

In the funicular domain, the partially saturated soils can undergo a collapse due to the only variations of water content. This phenomenon was studied under a wetting paths loading by Barden et al. (1973). In the literature, several models describe the collapse behaviour as Alonso et al. (1990) with a phenomenological model based on hydro-mechanical approach, or as Liu et al. (2003) with a numerical model based on the micromechanical approach by Discrete Elements Method.

In the pendular domain, the granular media are more sensitive to the water content, which can be at the origin of an apparent cohesion by capillarity; this behaviour has been shown by simple compression tests (Soulié et al., 2006) and by direct shear tests (Richefeu et al., 2006).

The aims of this experimental study is to identify and analyse the collapse phenomenon on a granular material constituted by a polydisperse assembly of glass bead during a wetting path from pendular domain to saturation with two different grain sizes. All samples are prepared with initial gravimetric water content $w_0 = 5\%$. This initial water content corresponds to pendular domain and thus creates capillary bridges between grains which cause apparent cohesion.

After the positioning of the sample in the triaxial cell. we arrange the axial and radial local sensors

on the sample. Local sensors are used for monitoring the evolution of axial and radial displacements at different points of the sample during the wetting path, without external stress. The wetting path is done by applying a gradient of water pressure ($u_w = 5$ kPa at the bottom of the sample by a pressure-volume controller).

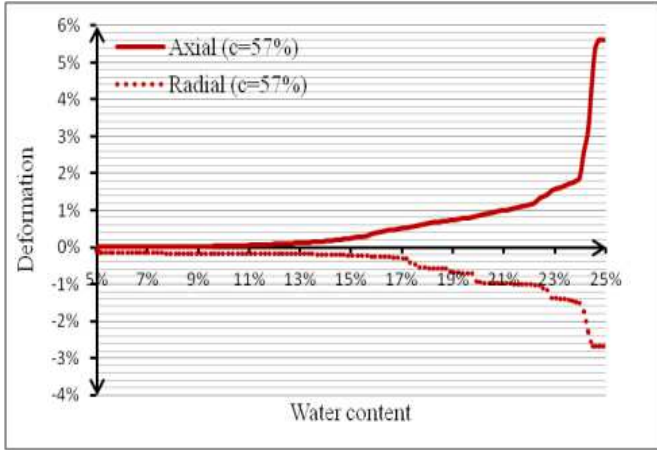
The experimental results during the wetting path show that the collapse of the granular assembly is purely due to hydraulic effects, caused by the progressive fusion of the capillary bridges. The scope of the collapse is even more significant for smaller grain size (Figure 1). This phenomenon can be explained by a large number of contacts (initial number of capillary bridges per volume). Our results show that the collapse depends on the density of the granular assembly and on the grain size.

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Illustrations

Glass bead $\Phi < 50 \mu\text{m}$



Glass bead $\Phi 100 - 200 \mu\text{m}$

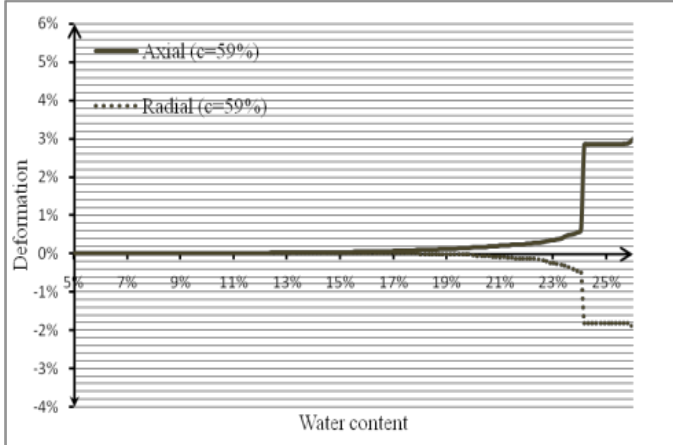
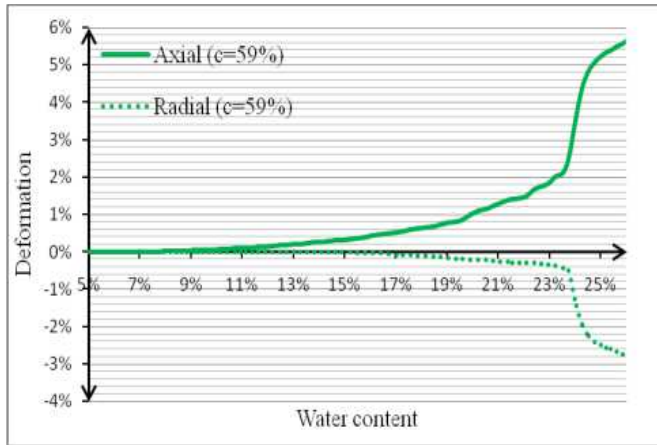
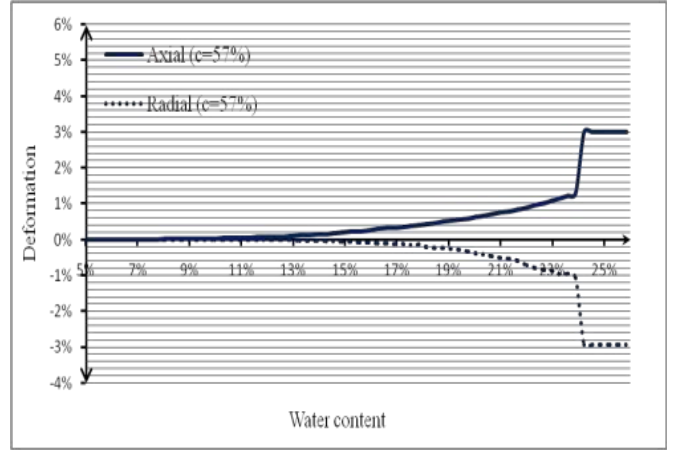


Figure 1: Axial and radial deformations during wetting of Glass beads:
 grain size $\Phi < 50\mu\text{m}$ a) $c = 57\%$; b) $c = 59\%$
 grain size $\Phi = 100-200\mu\text{m}$ c) $c = 57\%$; d) $c = 59\%$