Fabric analysis of internally unstable soils

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The fundamental mechanisms of internal instability operate at the particle scale. The particle fabric determines susceptibility to internal instability and empirical criterial such as those proposed by Kézdi (1979) quantify this fabric effect indirectly. This study examines a number of real sand samples with varying degrees of internal stability (as quantified using the Kézdi criterion) at the particle scale using high resolution micro-computed tomography (μCT). According to this criterion a soil is considered to be internally stable if $(D_{15}/d_{85})_{max} < 4$. Referring to the sieve data in Figure 1a, three specimens of sand with different grading and different levels of internal stability were created; one well graded specimen (WG), and two gap graded specimens (G1 and G2).

Dry samples of each material were prepared in a standard triaxial cell. As detailed in (Fonseca et al. 2014), each sample was prepared in an normally consolidated state. To enable analysis of the inter-particle contacts a resolution of 10μm was needed and so the sample size for micro computed tomography (μCT) scanning was restricted to 9mm diameter. These 9 mm cores were extracted without disturbing the fabric by impregnating the specimens with a low-viscosity epoxy resin. Three cores were extracted for each sample and they were scanned using a *phoenix nanotom* (GE Measuring & Control). Processing of the μCT data generated the binary images illustrated in Figure 1b and enabled quantitative analysis of the fabric of each sample.

Kenney & Lau (1985) propose that in an internally unstable soil there is a primary fabric of stress-transmitting coarse particles and there are loose finer particles in the voids between the primary fabric, which do not carry effective stress and can be moved by seepage. Referring to Figure 2, qualitatively it seems that these criteria are met for the gap-graded materials.

Segregation of the samples meant there was a slight variation in the particle size distributions measured from the μCT data and the average Kézdi ratios were 1.58, 3.95 and 4.12 for the WG, G1 and G2 samples respectively. Shire & O'Sullivan (2012) proposed that there is a relationship between the average number of contacts per particle (the sample coordination number) and the stability of the material as assessed using the Kézdi criterion. Their analysis was based on discrete element method simulations using spherical particles and highly simplified contact models. Quantitative analysis of the particle scale data obtained in the current study confirmed that the coordination number decreases monotonically with increasing Kézdi ratio.

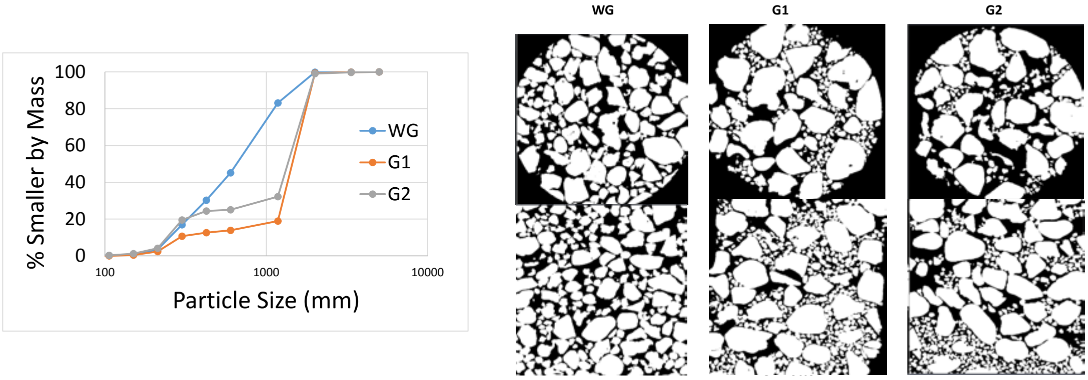

Figure 1a. Particle size distributions of materials considered and 1b. Representative μCT-derived images of material fabric

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