

Particle Breakage of Granular Soils: Evolution Laws and Constitutive Modelling

By

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Certificate of original authorship

I, Chenxi Tong declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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List of Publications

Journal papers

- (1). **Tong, C. X.**, Burton, G. J., Zhang, S., & Sheng, D. (2018a). A simple particle-size distribution model for granular materials. *Canadian Geotechnical Journal*, 55(2), 246-257.
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- (3). **Tong, C. X.**, Burton, G. J., Zhang, S., & Sheng, D. (2020a). Particle breakage of uniformly graded carbonate sands in dry/wet condition subjected to compression/shear tests. *Acta Geotechnica*. <https://doi.org/10.1007/s11440-020-00931-x>.
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Conference papers

- (1). **Tong, C. X.**, Zhang, S., & Sheng, D. (2018b). A Breakage Matrix Model for Calcareous Sands Subjected to One-Dimensional Compression. In GeoShanghai International Conference (pp. 17-24), Shanghai, China.
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In additions to the above papers, there are three journal papers (one in English, and two in Chinese) published during my MSc study in Central South University (CSU, China). These papers have served as the foundation of my PhD research.

- (1). Zhang, S., **Tong, C. X.**, Li, X., & Sheng, D. (2015a). A new method for studying the evolution of particle breakage. *Géotechnique*, 65(11), 911-922.

- (2). **Tong, C. X.**, Zhang, S., Li, X., & Sheng, D. (2015b). Evolution of geotechnical materials based on Markov chain considering particle crushing. *Chinese Journal of Geotechnical Engineering*, 37(5), 870-877. (In Chinese).
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Abstract

Granular soils are widely encountered in the construction of civil infrastructure. Particle breakage of granular soils results in changes in the particle size distribution (PSD), affects the stress-strain behaviour, and consequently reduces the serviceability of the infrastructure. It is of great importance to understand how the PSD of granular soils evolves under various loading conditions, and how the changes in the PSD affect the mechanical and deformational behaviour of soils. This PhD thesis-by-compilation provides a framework for studying the particle breakage of granular soils with specific attention on the quantification of PSD, breakage evolution law, and constitutive modelling.

The following primary contributions to the understanding of particle breakage of granular soils have been made through the doctoral research:

- (1). The appropriate breakage indices for granular soils with different initial PSDs are proposed and discussed.
- (2). The evolution of particle breakage in terms of the whole PSD, or in terms of a single breakage index is investigated via both experimental and mathematical approaches.
- (3). The influence of PSD on the compression and shearing behaviour of the soils are discussed.
- (4). A state-dependent constitutive model of granular soils experiencing particle breakage is developed based on a new state parameter and a dynamic evolution law of the critical state line and reference compression line.

This PhD thesis, which elaborates the work carried out during the course of the research, comprises four journal papers and two conference paper.