# Discrete element modelling of cohesionless, cohesive and bonded granular materials - from model conceptualisations to industrial scale applications

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## ABSTRACT

Handling and processing of bulk granular materials is of major importance in many industries including agriculture, chemical, food, pharmaceutical, construction and mining. In recent decades, the Discrete Element Method (DEM) is increasingly adopted for studying the complex behaviour of granular materials and simulating the industrial processes in many applications. DEM computes at individual particle interaction level and by incorporating relevant inter-particle forces and coupling with hydrodynamic forces of any surrounding fluid in particle-fluid systems, it provides important insights into the particle level phenomena – this in turn inform the bulk and industrial level processes.

In this keynote lecture, the developments of three DEM contact models to model: a) free flowing cohesionless solids; b) cohesive fine powders and c) cementitious materials are described. In particular, the meso-scale approach of modelling cohesive material is proposed using a visco-elasto-plastic frictional adhesive contact model developed recently at the University of Edinburgh [1,2]. The cohesive model reflects the physical phenomena of adhesive contact forces in fine cohesive particles and accounts for both elastic and plastic contact deformation with the adhesion being dependent on contact plasticity. Also a bonded contact model based on the

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Timoshenko beam theory which can be used to model concrete, rock and other deformable-breakable materials will also be presented [3].

The suitability of these contact models to predict real physical behaviours will be discussed. The scaling laws of the contact model parameters to produce the same load-deformation behaviour invariant of the particle size used in the simulations are presented [4,5]. Averaging (coarse-graining) technique based on statistical mechanics [6] is applied to the DEM particle data to provide important insights into the mobilized stress field during an industrial process. The studies demonstrate successful applications of DEM simulations of large scale applications using DEM models with appropriate scaling laws and material characterization experiments.

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