Open-source codes for particle-shape characterisation, simplification and generation in numerical models: From imaging data to polyhedra and multi-sphere particles

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ABSTRACT

The mechanical and rheological performance of particulate materials is directly affected by the morphology of their individual particles. Recent advances in imaging acquisition techniques provide valuable information on the internal structure of particulate materials, capture the morphology of single particles and shine light on properties of their arrangement and interactions. Most industrial applications and existing standards on shape characterisation are still based on two-dimensional projections of the particles. Though, two-dimensional shape characterisation has been criticised in the literature for its limited capacity to represent the morphology of real, three-dimensional particles. This study aims to demonstrate two new open-source codes, named SHAPE and CLUMP, which facilitate a seamless workflow from experimental imaging to numerical simulations. First, SHAPE is discussed to characterise the morphology of three-dimensional particles from imaging data [1], for all aspects of particle shape, namely form, roundness and roughness. Simplified polyhedral particles are generated at several fidelity levels, which can be used in finite element analyses or discrete element simulations. Second, CLUMP is demonstrated to generate clumps and clusters of multi-sphere particles using various approaches, directly from imaging data [2]. The surface of each clump can be tessellated as a surface mesh, and its morphology can be characterised using SHAPE. Combining these two frameworks, it becomes feasible not only to characterise the original material, but also the simplified representations of the particles, which are used in numerical simulations, allowing for a quantification of the reduction of morphological fidelity. Then, several case studies are demonstrated, where simplified polyhedral and multi-sphere particles are used to simulate triaxial tests of railway ballast, sand, and rice particles, highlighting the importance of particle shape on the mechanical response of granular materials.

REFERENCES

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