Characterisation of grain form and orientation of railway ballast assemblies with two fabric tensor-based methods

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ABSTRACT

The shapes and orientations of individual particles have significant influence on the macromechanical behaviour of a granular material. Therefore, several methods have been proposed to quantify these geometric features [1]. This study introduces the Surface Orientation Tensor (SOT) [2] and the Volume Distribution Tensor (VDT), two special weighted fabric tensors [3]. Application of the SOT and VDT on railway ballast assemblies is compared with the frequently applied Oriented Bounding Box (OBB) approach.

The SOT is based on the discretised surface of the grains, while the VDT is based on volume segments. A tessellation of the particle surface can be obtained by e.g. 3D scanning and the volume segments can be computed from the solid representation of this geometry. The VDT can also be determined directly on 3D images, derived using X-ray computed tomography, with the voxels serving as volume segments. Three shape indices, namely compactness, flakiness and elongation are computed from the eigenvalues of the tensors. Complementary, their eigenvectors show the major orientations of the grains, i.e. the orientations in which the grains are most/least likely to form contacts with other grains.

The dimensions of an OBB, i.e. a circumscribed cuboid of the grain, can also be used to compute compactness, flakiness and elongation, while their directions define the orientation of the grain.

The three shape characterisation methods are applied for convex and concave railway ballast grains. Assemblies are created from these grains and the geometrical orientations are compared with the orientation of the contact network (i.e. contact fabric), in triaxial loading conditions.

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