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Triaxial compression of granular aggregates: the role of contact forces

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We investigate grain-scale interactions and how they affect the macroscopic mechanical behaviour of granular aggregates. To this purpose we use Discrete Element Method (DEM) numerical simulations. These capture the evolution of an aggregate through integration in time of the equations of motion of its individual grains, which interact through contact forces.

We numerically simulate a 3D model material made of elasto-frictional cohesionless Hertzian spheres assembled in a homogeneous random isotropic aggregate. We focus on the linear elastic behaviour of these assemblies, which is especially relevant to wave propagation.

We fully characterize how grain displacements and corresponding contact forces accommodate a biaxial compression applied at the boundaries. We describe how, depending on ratio of tangential to normal stiffness at contacts, grain centre displacements or rotations dominate in accommodating the external load. We find that the macroscopic behaviour is completely determined by the average of normal and tangential relative displacements between contacting grains over equally oriented contacts. These two averages are proportional to the relative displacement that the average strain would induce at same orientation (average strain assumption), by proportionality factors which depend on coordination number (average number of neighbours per particle) and on the geometry of the neighbourhood of a contacting pair, which we characterise in statistical terms.

We present an analytical model which successfully predicts these averages and which is based on a Representative Elementary Volume of grains 4-diameters in size.