Particle and domain size scaling in terramechanical simulations

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ABSTRACT

DEM is a versatile but computationally intensive method for granular dynamics simulation. The computational intensity is largely tied to the number of particles and time-step, which itself is influenced by both particle size and simulation domain [1]. While the effect of particle size has been investigated in DEM, little work has been done to explore the impact of varying the particle size distribution spatially throughout the simulation domain or altering the domain size itself.

In order to characterize the errors introduced by the domain truncation and variations in particle size distribution, we conducted numerous simulated plate traction tests. Specifically, we perform pressure-sinkage and shear-displacement tests using a plate with grousers on a soil bed confined in a rectangular bin. See Fig. for an example. Throughout the tests, we measure the distribution of inter-particle forces and displacements, which we then analyze and coarse-grain into fields of stress and strain.

In the domain scaling analysis, we use spatially uniform and spatially varying particle size distribution. We study how the error depends on the depth and width of the domain, including the smooth transition from 3D to quasi-2D, and the plate's proximity to the confining bin's walls.

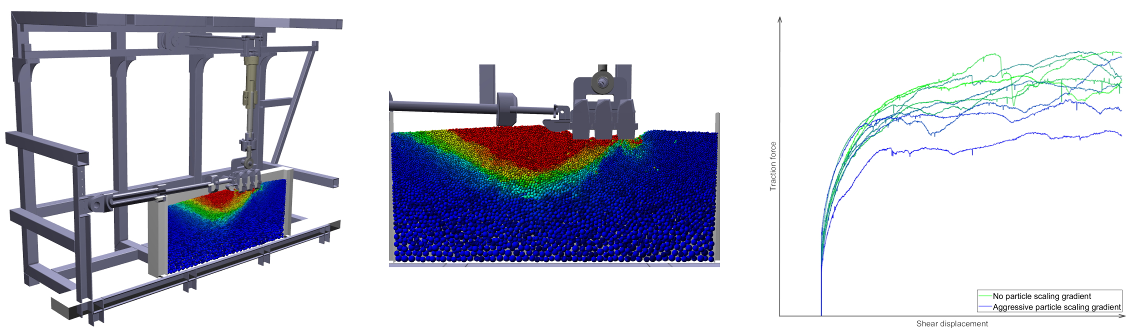

Figure 1: The traction plate test rig with particles color-coded by the velocity and sample traction-displacement curves for different particle scaling gradients.

When studying the spatially varying particle size distribution, we have implemented a method that changes the particle size in a gradient going from a fine particle resolution close to the plate to a coarser resolution further away. A surprisingly aggressive gradient can be used, where the fine particles are only a fraction of the grouser size, and the large particles are up five times as large. This approach has a small effect on the pressure-sinkage and shear-displacement relations, and enables a reduction in computational effort by nearly an order of magnitude.

REFERENCES

[1] M. Servin, D. Wang, C. Lacoursière, and K. Bodin. Examining the smooth and nonsmooth discrete element approach to granular matter. *Int. J. Numer. Meth. Engng.*, 97:878–902, 2014.