

How do we determine the statistically sufficient number of simulation runs in Discrete Element Method?

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The Discrete Element Method (DEM), a numerical simulation technique for particulate systems, becomes a powerful tool to investigate the mechanical behavior of granular assembly including geo-materials such as sands, fault gouges, and sand-stones. Although the DEM can simulate strongly non-linear phenomena (e.g., debris flow, shear banding, and faulting), it is difficult to assess a single case-study result of the DEM simulation because the simulation result is largely sensitive to simulation setting: initial particle configuration; intensity of confining pressure; number of DEM particles; particle shape, etc. In addition, different initial particle configurations with the same physical properties of DEM particles often produce result in different mechanical behaviors.

These facts are directly linked to the reliability of the knowledge derived from the simulations so that we have to statistically verify the number of DEM simulation runs that is sufficient to obtain both the reliable and averaged

physical quantities from the DEM simulations.

This report provides a basic procedure to verify DEM simulation runs based on both the coefficient of variation and the well-known theorem in statistics, i.e., Central Limit Theorem (CLT). I conducted in total 16 cases of simple shear DEM simulations with 1000 runs for each case to determine the sufficient number of simulation runs for evaluating the averaged peak and residual strengths.

The outcomes from the series of DEM simulations are summarized as follows:

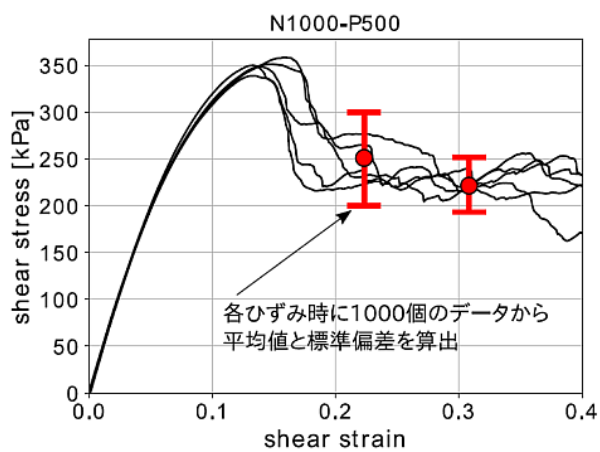
(1) At least 10 simulation runs are required for evaluating the average residual strength with 1000 DEM particles under the initial confining pressure of 500 kPa.

(2) The required number of runs depends on both the confining pressure and the number of DEM particles.

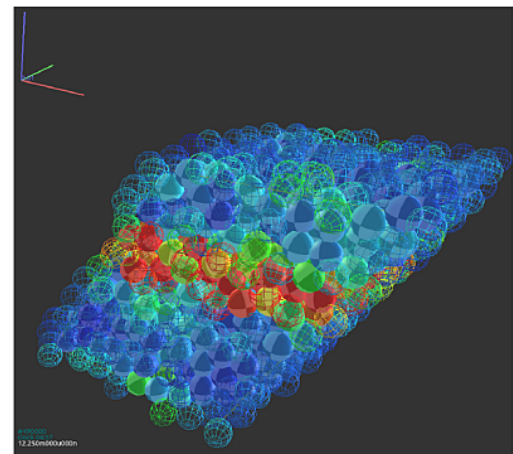
(3) An increase in the number of DEM particle is more effective to reduce the simulation runs than that in confining pressure.

(4) A certain number of simulation runs is required to define the shear elastic modulus at the beginning of shearing because the coefficient of variation is large at small strains close to zero.

Keywords: Discrete element method, Central limit theorem, Coefficient of variation, Simple shear, Number of simulation runs



(a) せん断応力-せん断ひずみ関係



(b) せん断終了時 (ひずみ40%)のスナップ
(色は粒子回転量を示す)

図1: (a) シミュレーションから得られるせん断応力-せん断ひずみ関係の例,
(b) 40%せん断時のせん断帯の様子

Fig 1: (a) Samples of shear stress – shear strain curves,
(b) Snapshot of a simulation model in shearing with the shear strain of 40%.