A DEM study on the degree of mixture of soil particles stirred by rotation of rods

個別要素法による土の撹拌と混合に関する基礎的検討

Discrete element method (DEM) is used to simulate the stirring process and evaluate the degree of mixture at each rotation of stirring bars based on the initial positions of particles. This study focuses on monodispersed spherical particles where inter-particle cohesion is not considered.

シールドトンネルのチャンバー内の土の撹拌と混合度を評価するために、個別要素法を用いて、同一サイズの球形粒子を撹拌棒を回転させて撹拌する場合の混合特性について評価した。

Simulation steps

Particle Properties

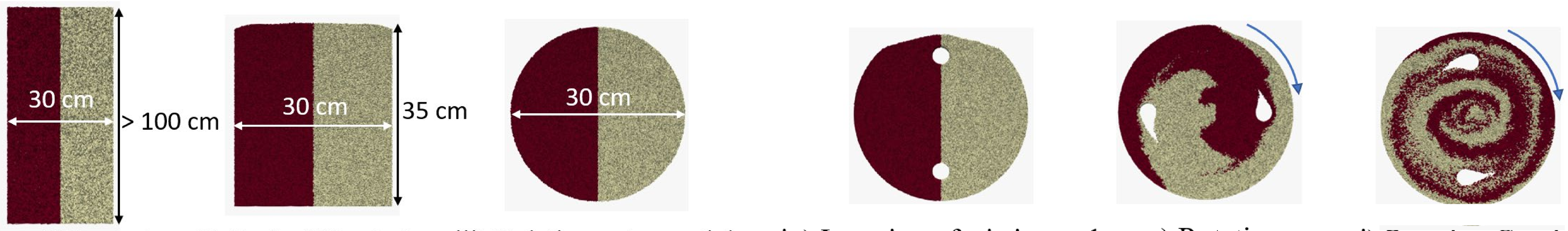
Inter-particle friction coefficient = 0.05

Young's modulus = 71.6 GPa

Poisson's ratio = 0.23

Diameter = 2 to 2.2 mm

Density = 2650 kg/m³

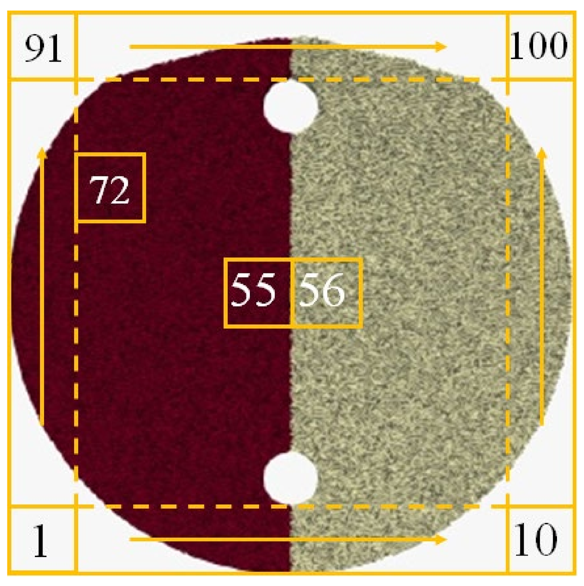


i) Start of Pluviation ii) End of Pluviation iii) Deleting extra particles iv) Insertion of stirring rods v) Rotation vi) Rotation Continued

Definition of degree of mixture

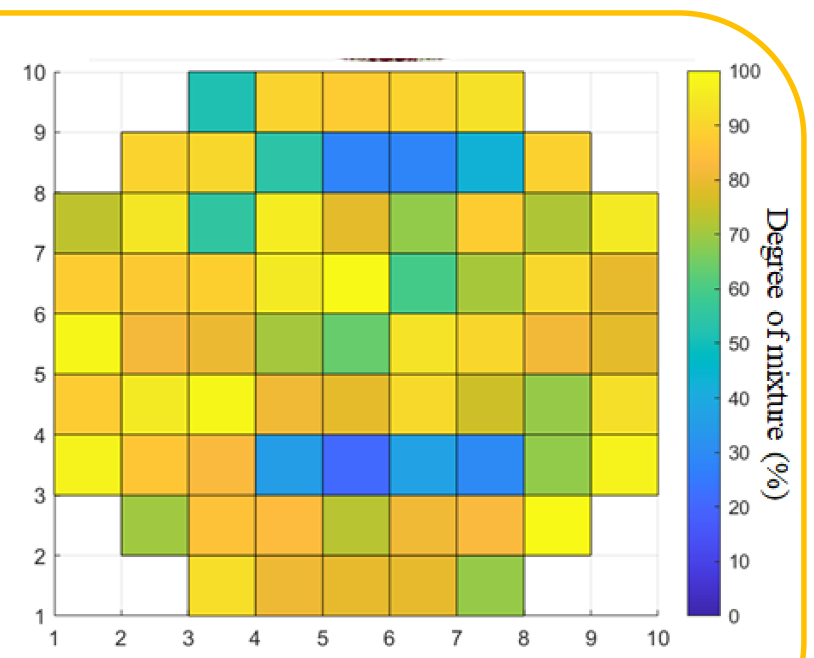
For **local degree of mixture (d_m)**, the particles were divided into the two regions (color 1 and color 2). The specimen was divided into one hundred equal-sized grids (10×10). For each grid, the d_m value was defined based on the difference in the numbers of type 1 and type 2 particles as follows.

$$d_m = \left(1 - \frac{|n_1 - n_2|}{n_1 + n_2}\right) \times 100$$



Grid system

Mixed specimen



Spatial distribution of *m*

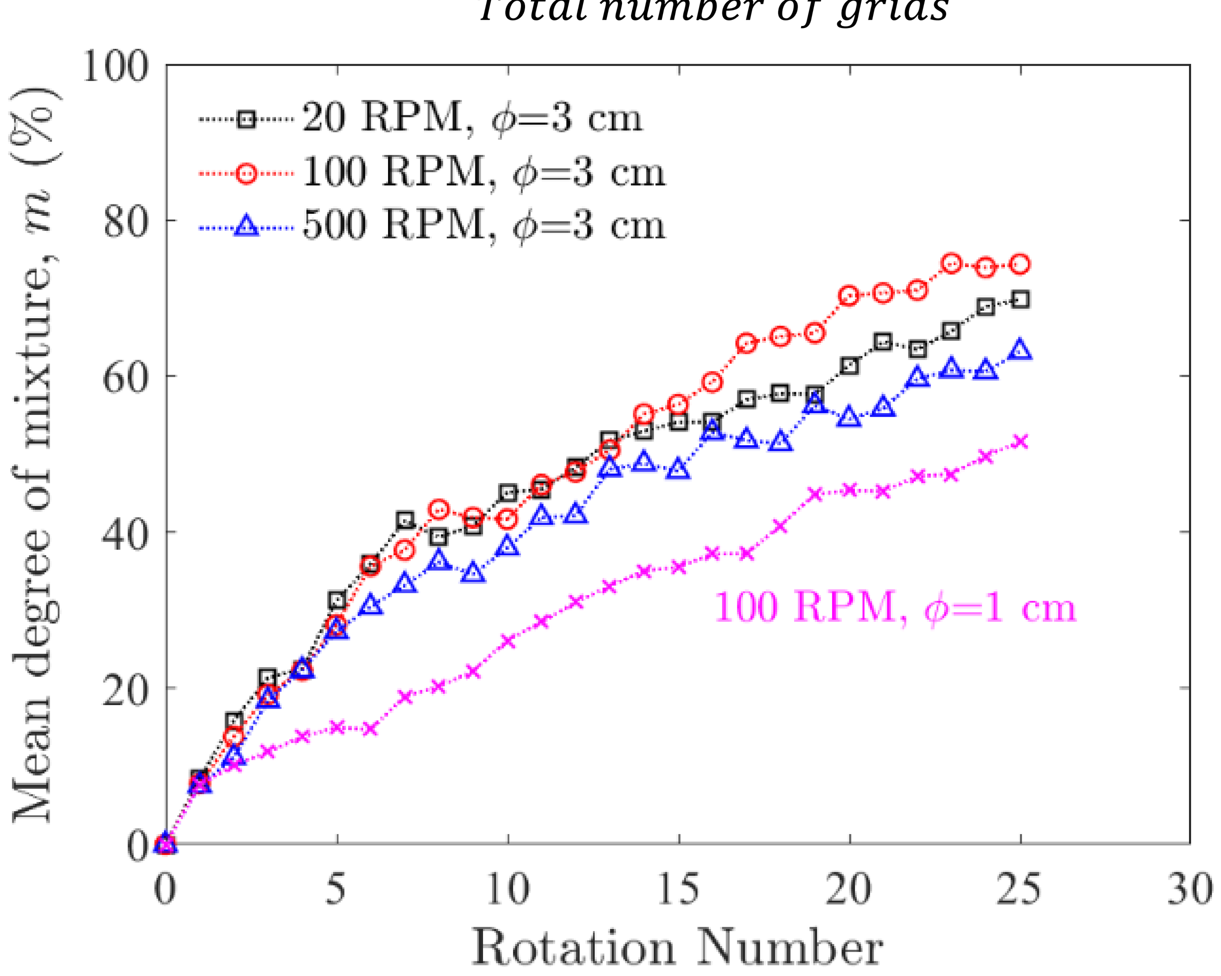
Evaluation of degree of mixture

20 RPM (φ=3 cm) 100 RPM (φ=3 cm) 500 RPM (φ=3 cm) 100 RPM (φ=1 cm)

Effects of mixing rate and size of stirring rods on the mixing condition after 25 rotations.

The **mean degree of mixture (*m*)** is defined by calculating the mean of d_m of all the grids at the given rotation number using the following equation.

$$m = \frac{\sum(d_m \; for \; all \; grids)}{Total \; number \; of \; grids}$$



Mean degree of mixture for different cases

Effect of the mixing rate of stirring rods

It is not easy to differentiate the degree of mixture by eyes. The left figure compares the evolution of *m* with the rotation number. The mixing rate appears less sensitive to *m* where there is no clear dependency of the mixing rate in the given results. It is noteworthy that the current simulation study focuses on non-viscous coarse particles only.

Effect of the size of stirring rods

The larger rods (i.e., diameter (φ) = 3 cm) are more effective to achieve higher *m* for a given rotation number at the same rate of rotation. Some locally concentrated zones for the two different colors are observed in Case 4 (φ = 1 cm), probably due to the less influenced zone generated by the motion of smaller rods during rotation.

For further information, contact below.
Prof. Reiko Kuwano
Bw-304, Institute of Industrial Science, the University of Tokyo
TEL: +81-3-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp

Ali Naqi（2022）
桑野研究室
東京大学 生産技術研究所 Bw-304
電話: 03-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp