D101

DEM-Based Numerical Investigation of Size Segregation in Ring Shear Tests: Model Improvements, Validation, and Analysis

〇Yuxuan LUO, Gonghui WANG

1 Introduction

Particle size segregation is a common occurrence in rock avalanches[1-3]. Studying their movement mechanisms and disaster effects is of significant practical importance. This research employs ring shear tests combined with numerical discrete element method (DEM) to validate suitable contact model and figure out the relationship between shear-weakening in ring shear tests of bi-disperse granular materials and size segregation phenomenon.

2 Methodology

Considering the limitations in observation and data acquisition inherent in experimental measurements, this study aims to further investigate the role of size segregation during the ring shear process using the discrete element method (DEM) [4].

Based on a comprehensive literature review and numerical investigations, the rolling resistance (R-R) contact model was selected after comparing several fundamental contact models for simulating the ring shear tests[5-6].

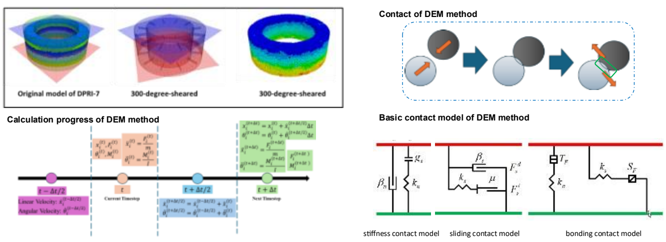

Fig 1. Discrete element method

Figure 1 illustrates the basic framework of the DEM approach, which has become a mainstream computational method for simulating discrete granular flows.

Figure 2 presents the construction of the numerical model used in this study. Based on ring shear experiments conducted with the DRPI-7 apparatus, the contact model was validated from three perspectives: shear behavior, flow behavior, and segregation behavior.

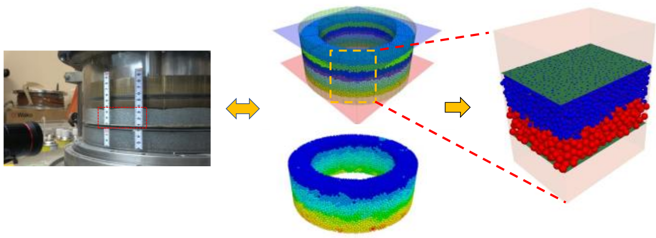

Fig 2. The numerical set-up compared with ring shear tests

3 Results

First, the R–R contact model was validated against ring shear experiments conducted using the DPRI-7 apparatus. Figure 3a compares the shear and normal stresses, where the blue curves represent the simulation results and the red curves represent the experimental measurements. Figure 3b further presents the peak and residual shear stress values extracted from Fig. 3a. Both figures demonstrate that the simulation results are in good agreement with the experimental data.

Subsequently, more detailed validations were performed, as shown in Fig. 4. Figure 4a illustrates the flow behavior, while Fig. 4b presents the sinking distance of small particles. These results indicate that the simulated flow and size segregation behaviors also agree well with the corresponding experimental observations.

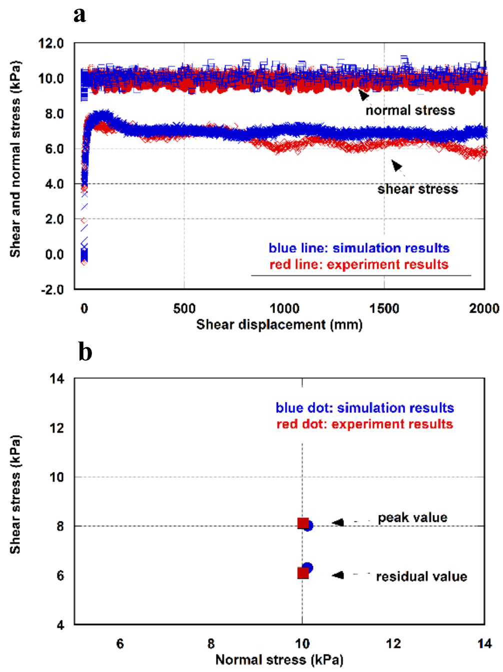

Fig 3. Basic validations of R-R contact model. a: comparison of shear and normal stress; b: comparison of peak and residual value in shear stress.

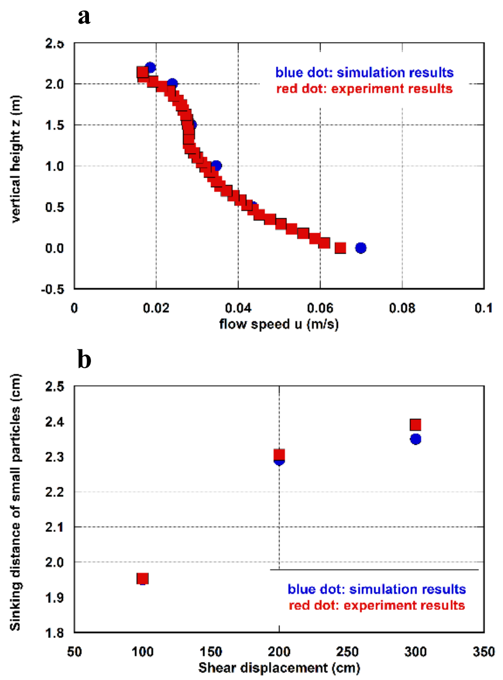

Fig 4. Detailed validations of R-R contact model. a: comparison of flow speed; b: comparison of sinking distance of small particles.

4 Conclusion

Based on ring shear experiments and a systematic literature review, the rolling resistance (R-R) contact model was adopted and validated. The results shows that the R–R model effectively captures both shear behavior and size segregation in bi-disperse ring shear tests.

5 Further plans

On the basis of the validated R–R model, this study will proceed with the following analyses:

1. Find if shear-weaking can be replicated by cyclic boundary in DEM simulations.
2. Explore the reasons of shear-weakening in DEM simulations of bi-disperse granular flows based on ring shear tests.

References

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