The 2025 World Congress on
Advances in Structural Engineering and Mechanics (ASEM25)
BEXCO, Busan, Korea, August 11-14, 2025

A Novel Clump-Based Breakage Model in Discrete Element Method for Simulating Crushable Aggregates

*Pei Wang[1)], Chengkai Xu[2)], Xiang Gao[3)], Jingjie Wu[4)]

[1), 4)] *School of Civil Engineering and Architecture, East China Jiaotong University, Nanchang 330013, China*
[2), 3)] *Department of Civil and Environmental Engineering, Hong Kong Polytechnic University, Hung Hom 999077, China*
[1)] *peiwang@ecjtu.edu.cn*

ABSTRACT

Particle breakage significantly influences the mechanical properties of granular materials at both macro and micro scales, while particle shape also plays a crucial role in various simulations. In current discrete element method (DEM) approaches, clumps, which are composed of multiple overlapping spheres, have been widely adopted as an efficient technique to represent real particle shapes. However, due to the inherent nature of clumps, which do not consider internal interactions between sub-particles, they cannot be directly employed to simulate particle breakage. To address this limitation and bridge the gap between particle shape representation and breakage simulation, this study proposes a novel clump-based method for simulating particle breakage in DEM. The proposed method introduces a breakage criterion based on the statistical stress analysis of clump particles. The location of breakage initiation and propagation is determined by evaluating the stress level of the sub-spheres constituting the clump. By leveraging extensive single-particle crushing studies and summarizing the observed patterns, a breakage mode criterion that integrates three-dimensional Voronoi tessellation is proposed. The sub-spheres within the clump are utilized to capture the actual stress concentration characteristics of the particle, enabling the definition of breakage modes. The accuracy and robustness of the proposed method are validated through a comprehensive series of single-particle and multi-particle experiments, demonstrating its ability to reproduce realistic breakage patterns and force-displacement responses. Compared to existing DEM breakage methods, the proposed model better considers the local stress concentration characteristics of particles and captures the influence of multiple contact forces on continuous crushing, while the clump-based breakage algorithm efficiently balances computational efficiency. This innovative approach provides a solid foundation for future research on breakage simulations considering

---

1) Professor
2) Graduate student
3) Graduate student
4) Assistant professor

particle morphology, offering a powerful tool for accurately modeling particle breakage in granular materials.

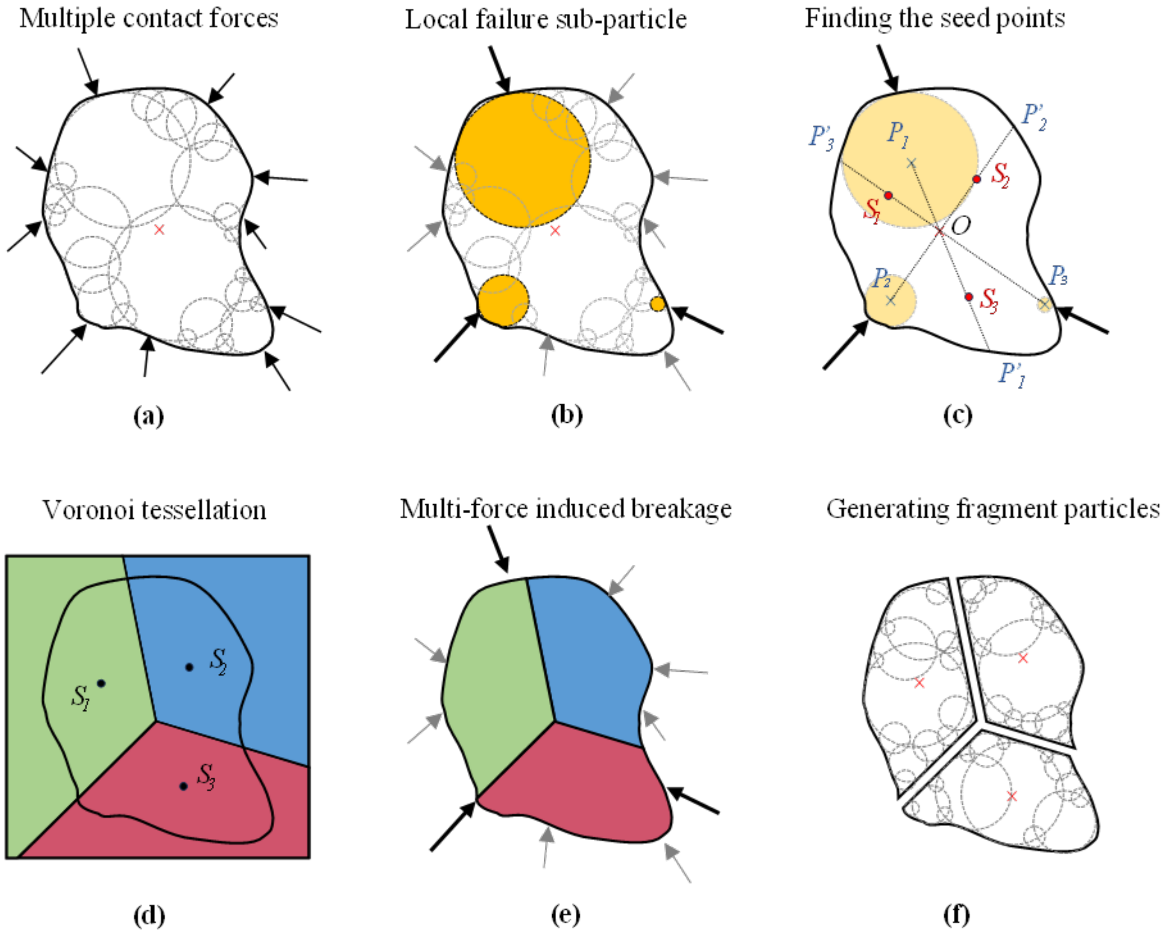

Fig. 1 Two-level breakage approach and its fragmentation scheme