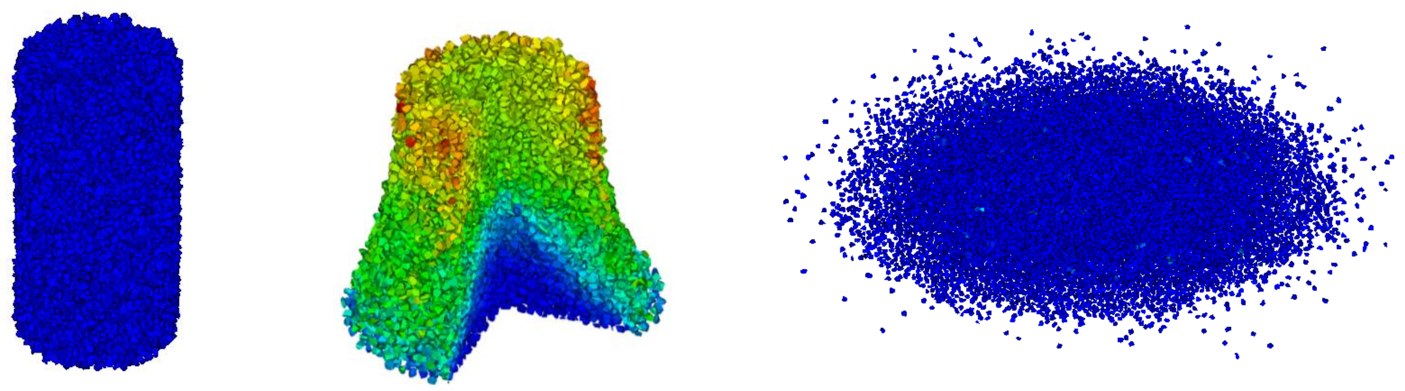
Finite-size analysis and the influence of the cross-section shape of the granular column collapses

T. Man[1], H. E. Huppert[2], L. Li[1], S. A. Galindo-Torres[1]

[1] Westlake University, Hangzhou, China; [2] University of Cambridge, Cambridge, UK

1. Granular column collapses and DEM



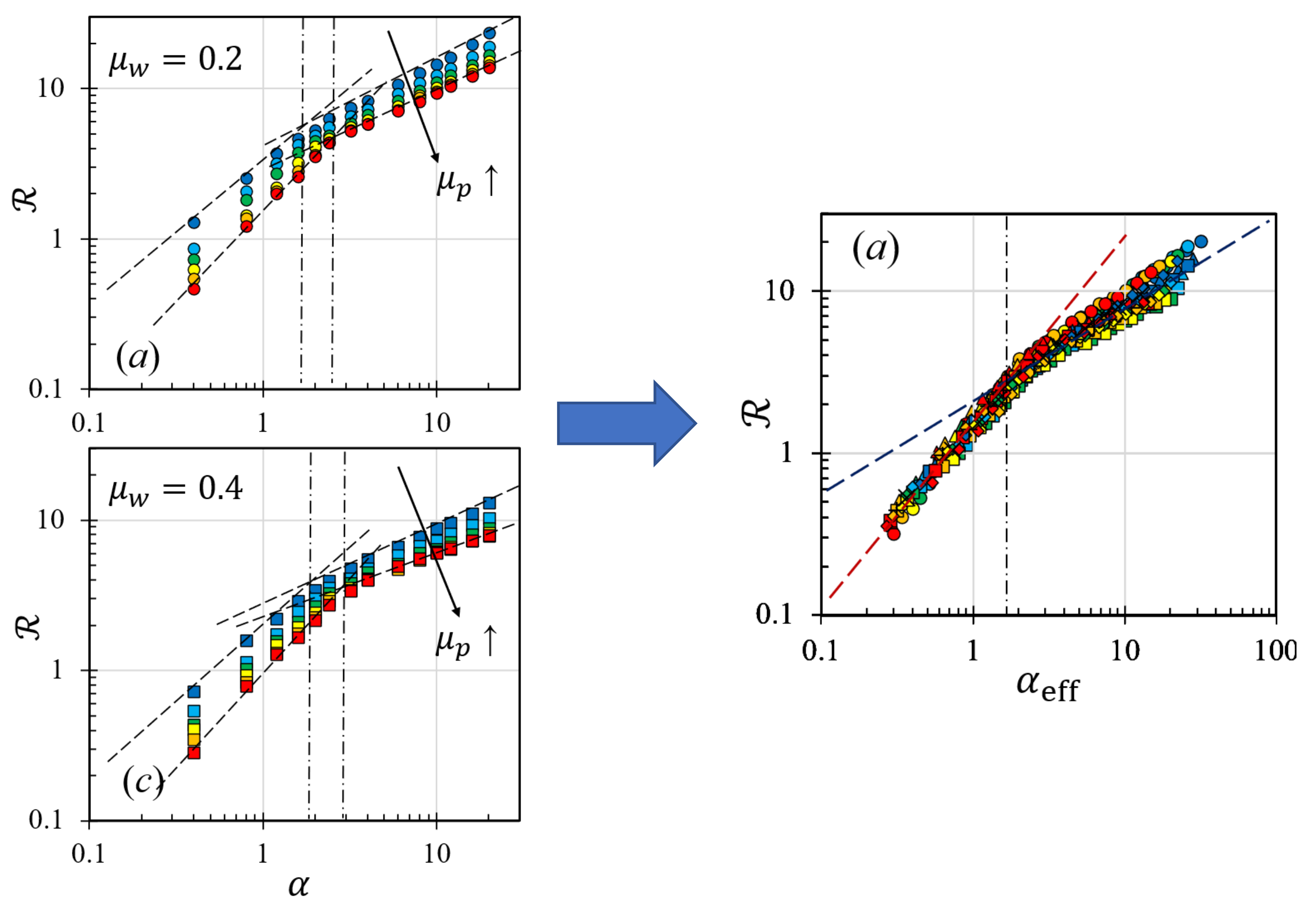
Voronoi particle discrete element method with linear spring and dashpot

2. Effective initial aspect ratio

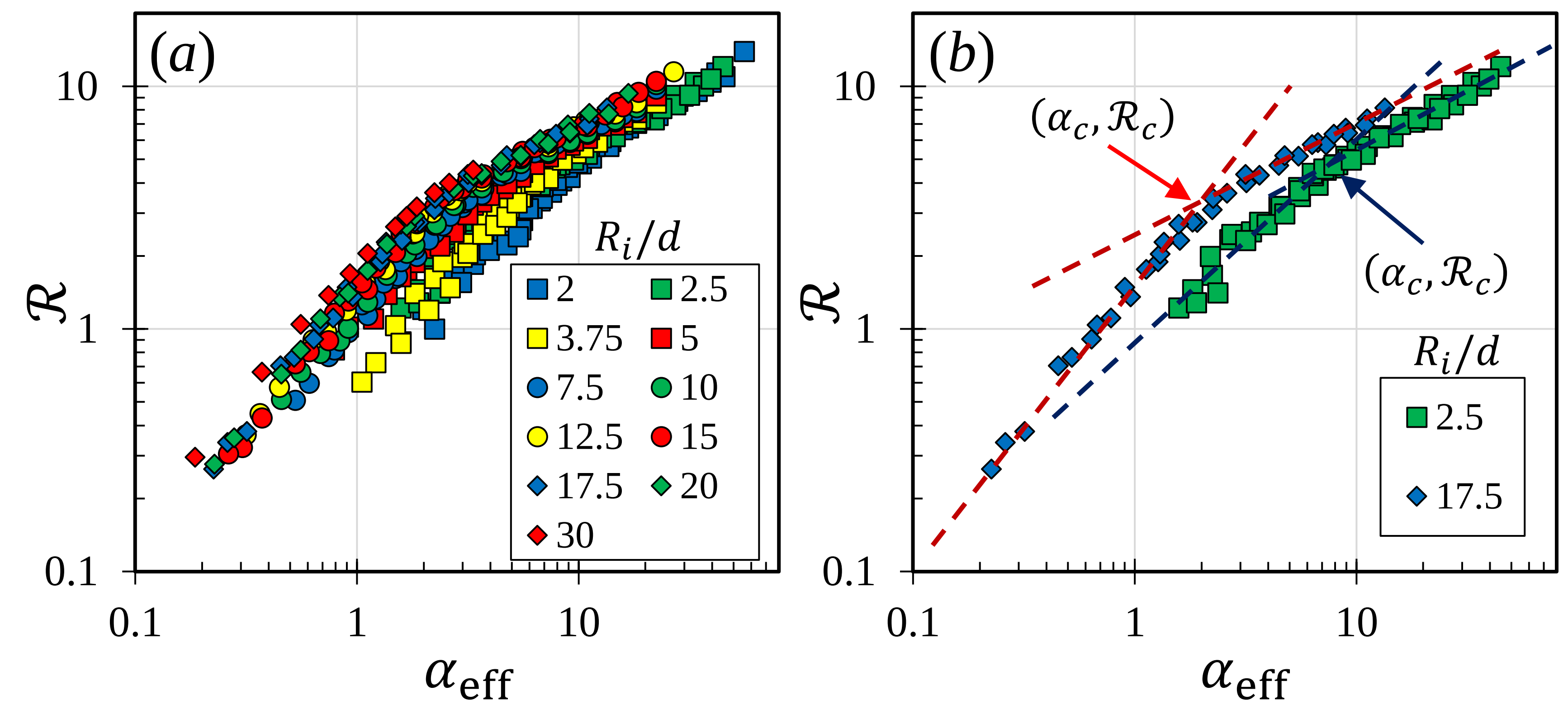
$$m_p \frac{d}{dt}\left(\frac{d\vec{x}}{dt}\right) = F_n\hat{n} + F_t\hat{t} + m_p g\hat{z}$$

$$\mathcal{J}_1 = f(\phi_s)g(\mu)\left(\frac{H_i}{R_i}\right)^2\left(\frac{R_i}{d}\right)^3 \qquad \mathcal{J}_2 = \frac{H_i}{R_i}$$

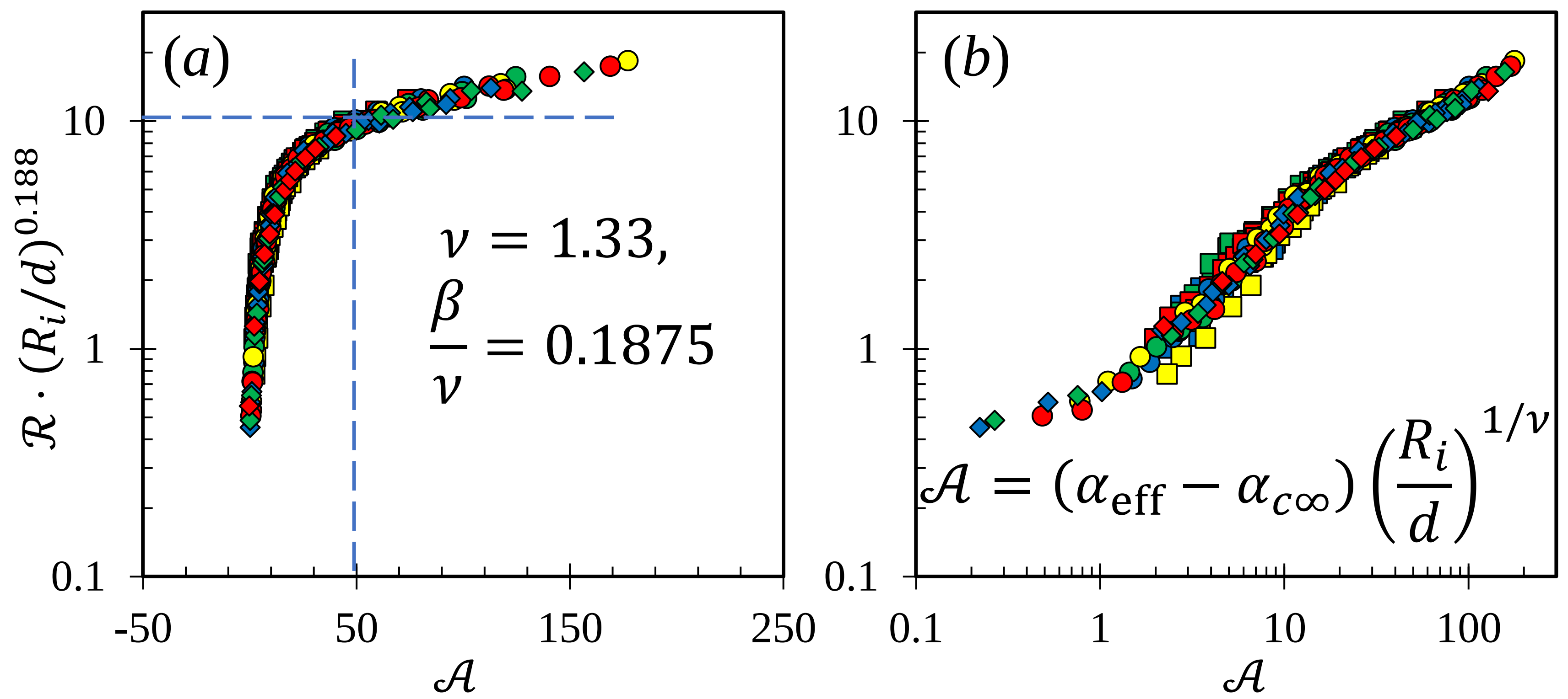
Effective initial aspect ratio $\alpha_{\text{eff}} = \sqrt{\frac{1}{(\mu_w + \beta\mu_p)}}\left(\frac{H_i}{R_i}\right)$



3. Size effect of granular column collapses



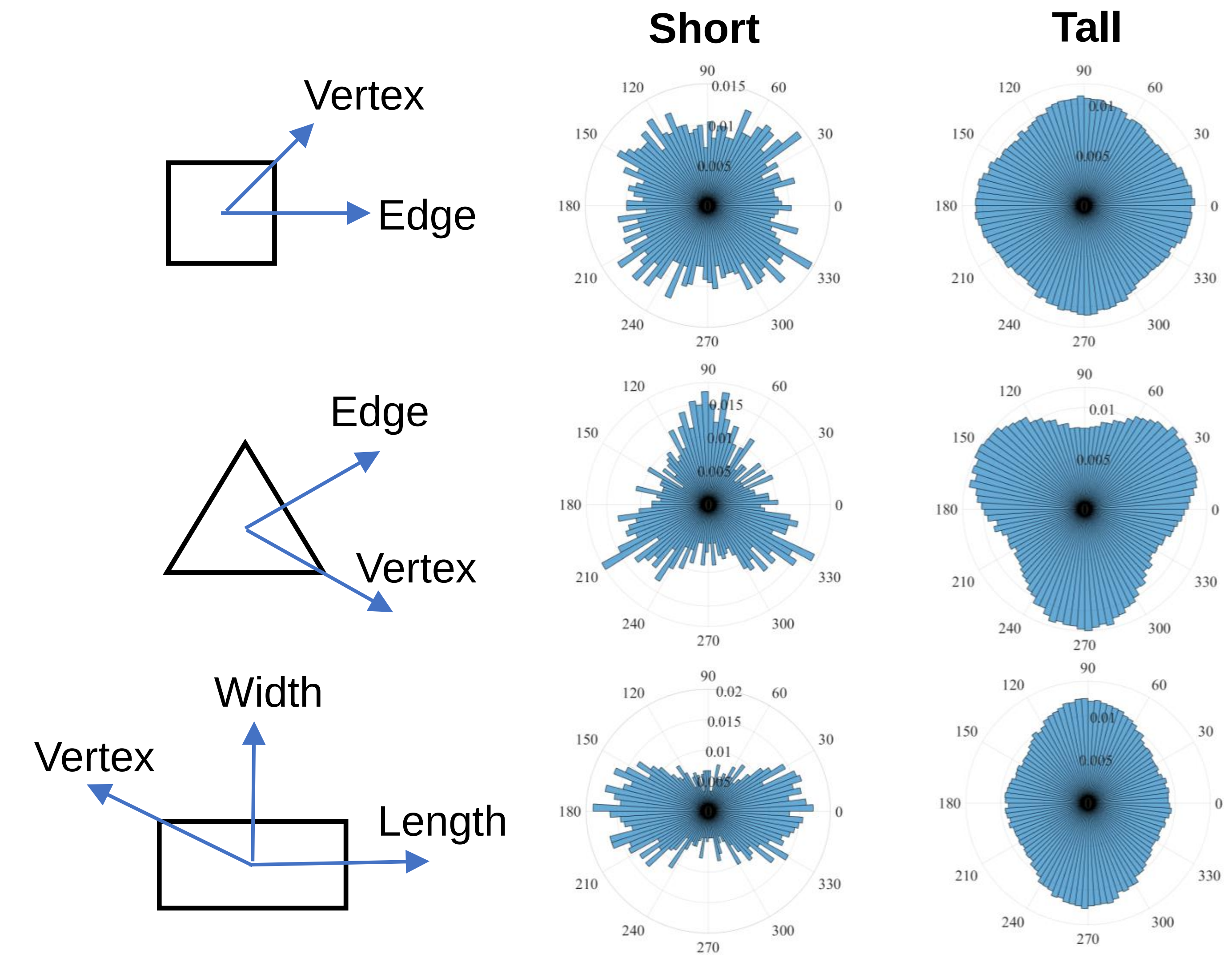
Finite-size analysis:

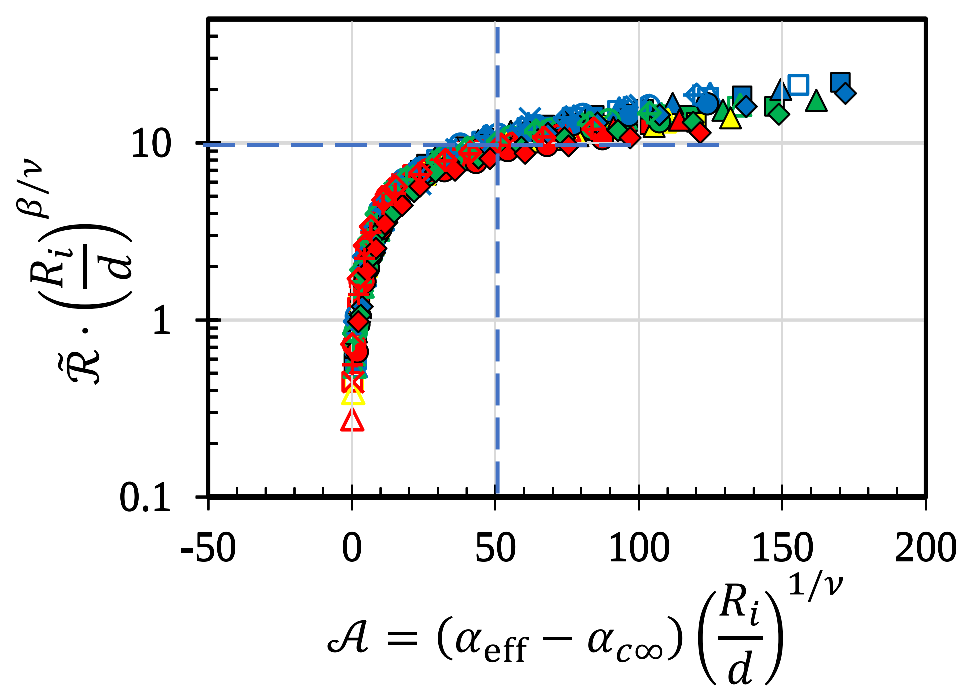


$$\mathcal{R} = \left(\frac{R_i}{d}\right)^{-\beta_1/\nu}\mathcal{F}_r\left[(\alpha_{\text{eff}} - \alpha_{c\infty})\left(\frac{R_i}{d}\right)^{1/\nu}\right]$$

4. Influence of the cross-section shape

The shape of the cross-section of a granular column can also influence the run-out behavior and the deposition pattern. Here, we investigate three types of cross sections: (1) **square**; (2) **equilateral triangle**; (3) **Rectangle**





A figure with all types of columns: Square, equilateral triangle, 6×3 rectangle, and 8×2 rectangle; and different directions: vertex, edge, width, and length.

$$\tilde{\mathcal{R}} = \frac{(R_\infty - R_i)}{\sqrt{Area/\pi}}$$

5. Conclusions

- The run-out behavior of granular column collapses can be described by an effective initial aspect ratio α_{eff}.
- The relative size R_i/d and the cross-section shape of a column plays important roles in the behavior of granular column collapses.

6. References

[1] T. Man, H.E. Huppert, L. Li, S.A. Galindo-Torres, Granular Matter (accepted), 2021

[2] T. Man, H.E. Huppert, L. Li, S.A. Galindo-Torres, arXiv preprint: arXiv:2012.03287