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Development and Applications of DEM Digital Twins of Powder Systems

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Digital Twins - Clarification

- Data exchange from real equipment to digital twin
- In this case not real time
- Copy of the real piece of equipment



Fig 2: GranuFlow (left) and digital twin of the GranuFlow (right).



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Application of Digital Twins for a New DEM Calibration Methodology

Direct Testing

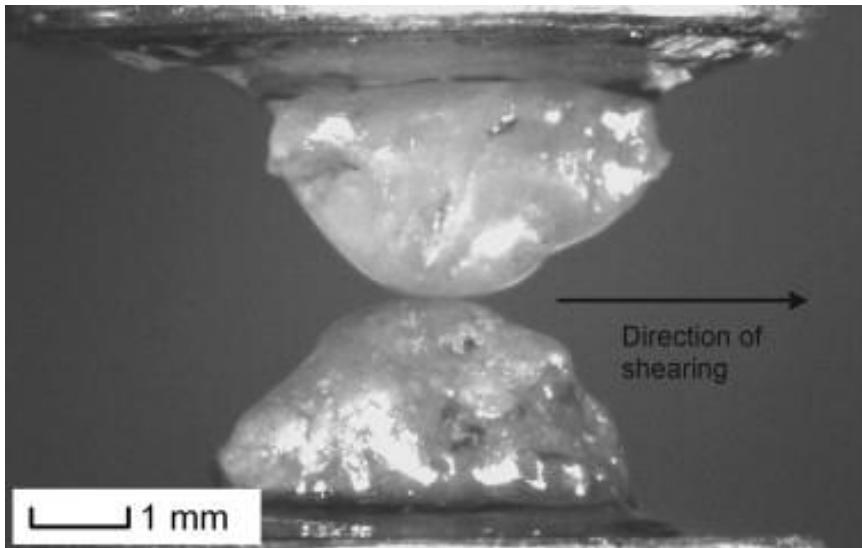


Fig 3: Direct measurement of frictional properties.

Senetakis K, Coop MR, Todisco MC. The inter-particle coefficient of friction at the contacts of Leighton Buzzard sand quartz minerals. *Soils and Foundations*. 2013;53(5):746-55.

Bulk Calibration

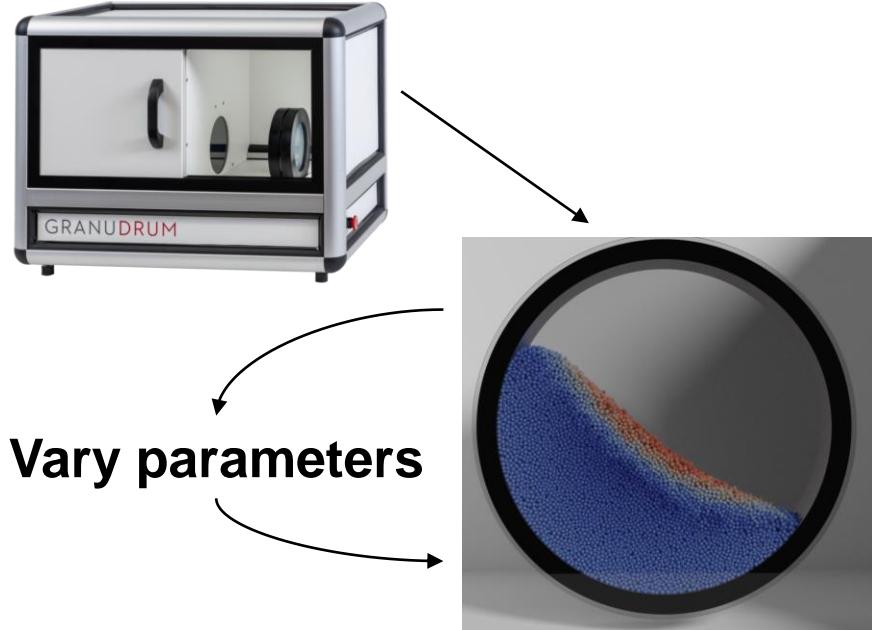


Fig 4: Bulk calibration diagram.

Mapping Relationship

Bulk Properties

Flowability

Angle of Repose

Tapped Density

Dynamic Angle of Repose

Mapping Relationship

Microscopic Properties

Restitution

Poison Ratio

Particle Friction

Cohesive Energy Density



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Digital Twins of Powder Characterisation Tools

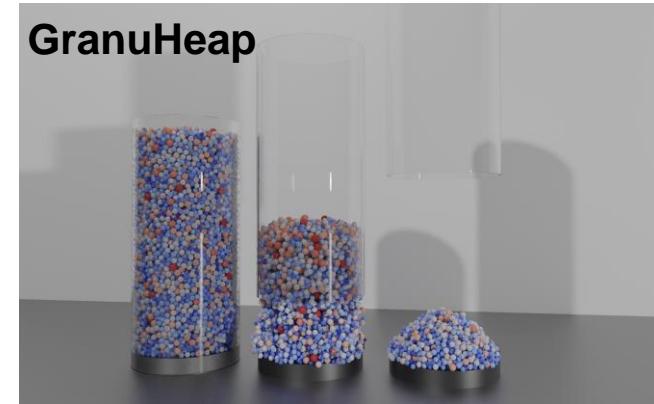
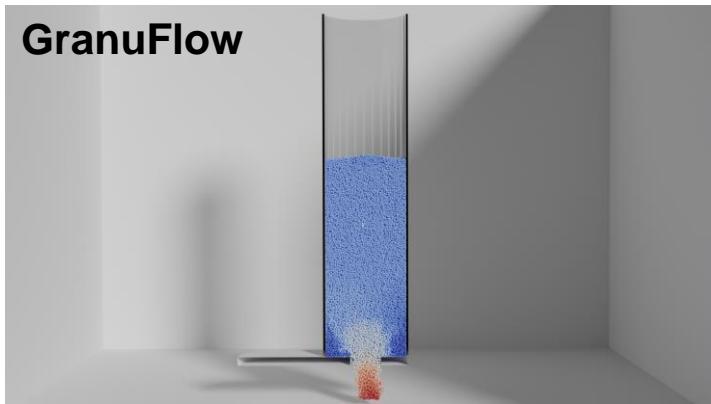
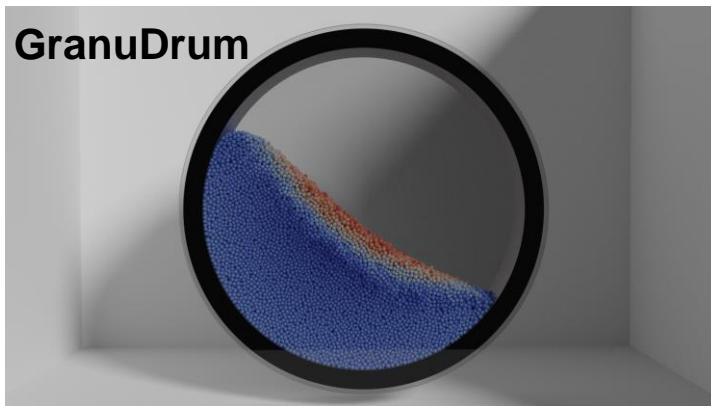
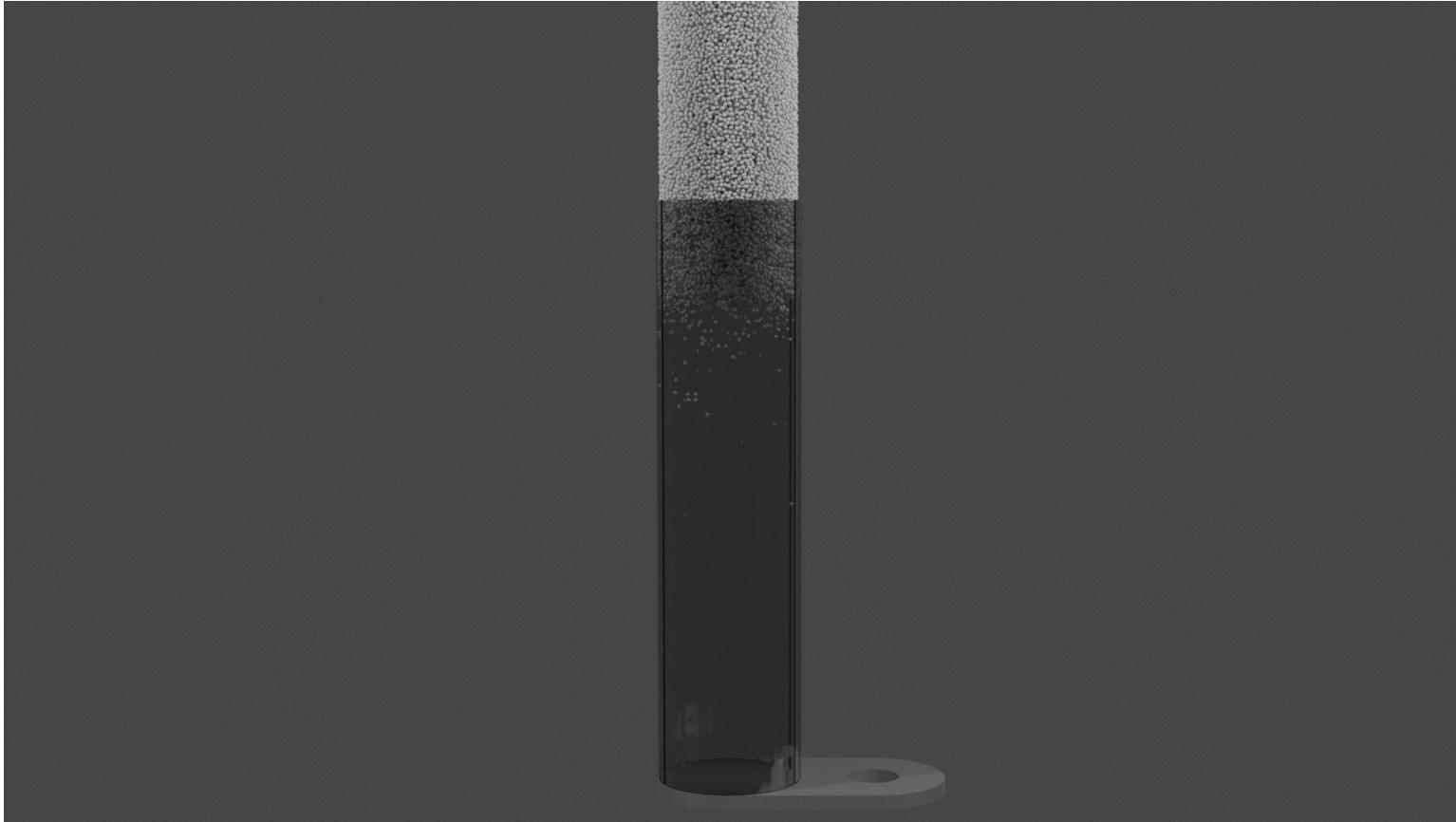


Fig 5: Currently finished digital twins.

GranuFlow Digital Twin



Validation

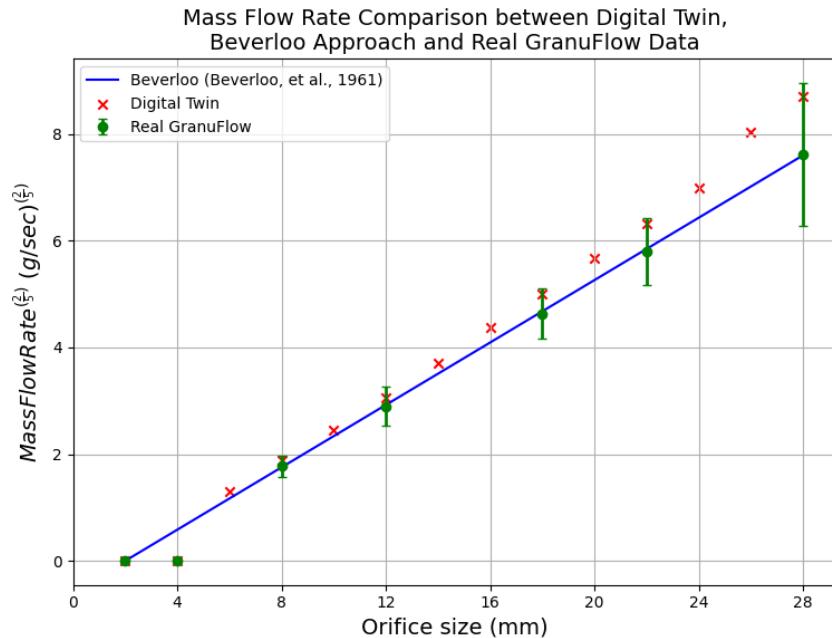
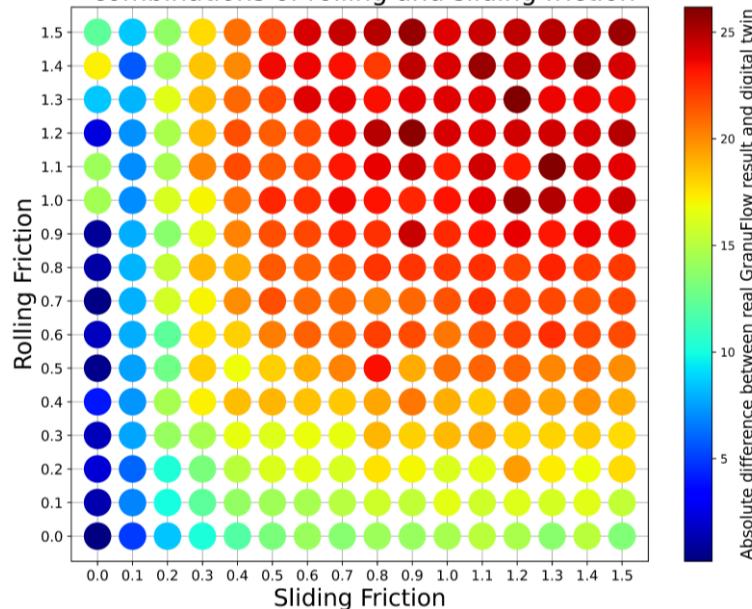


Fig 5: Validation of GranuFlow digital twin results with data from a real GranuFlow and the Beverloo approach.

Error between Real GranuFlow and Digital Twin for different combinations of rolling and sliding friction



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Beverloo, W. A., Leniger, H. A. en van de Velde, J. (1961) "The flow of granular solids through orifices", *Chemical Engineering Science*, 15(3), bll 260–269. doi: 10.1016/0009-2509(61)85030-6

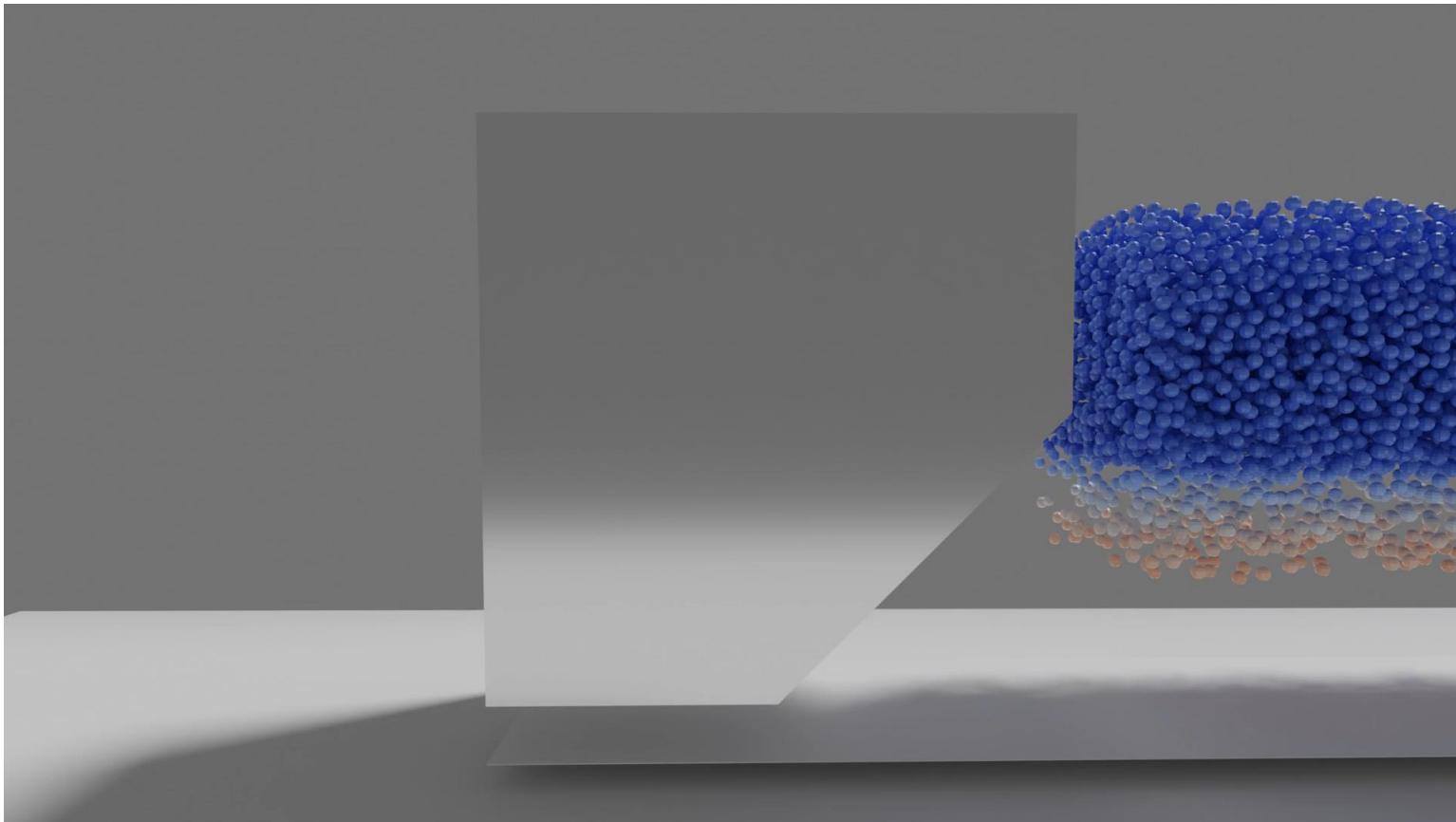
Results

Variation of Dynamic Angle of Repose with DEM Parameters for largest particle size and restitution of 0.9.

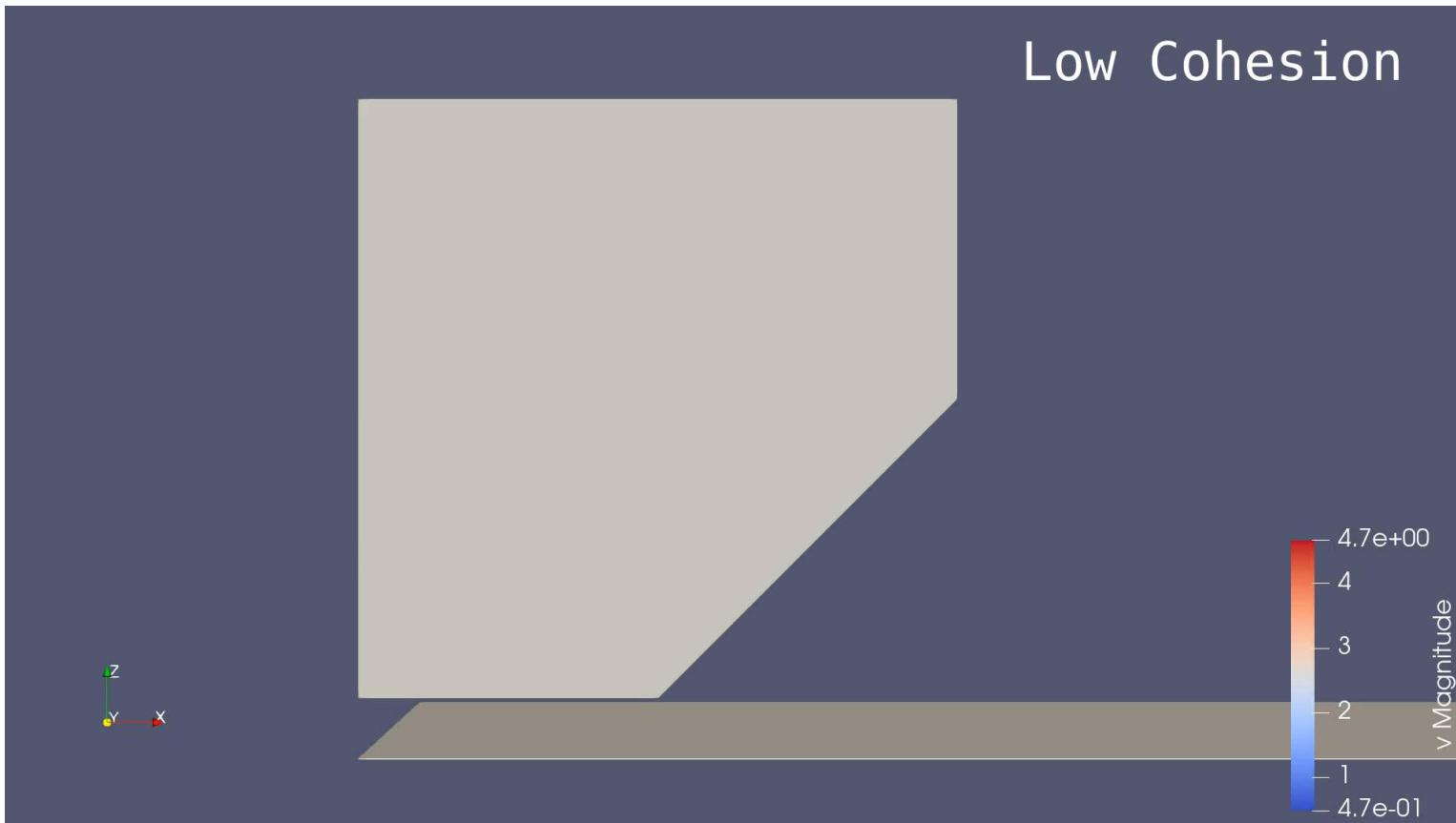


Fig 5: Results of a parameter study looking at the change in dynamic angle of repose due to different values for DEM parameters.

Additive Manufacturing Spreader Digital Twin



Effects of Cohesion



Future Work

- Develop an automated way of finding optimal height and blade speed using the additive manufacturing spreader digital twin.
- Develop a way of mapping the bulk properties measured to the microscopic parameters in powder simulation.
- Develop the GranuCharge and implement electrostatics contact model into DEM.



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Any Questions?

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