

# John Paul Morrissey, Ph.D.

Research Associate, School of Engineering






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🌐 <http://www.linkedin.com/in/jpmorr/>  
🎓 <https://scholar.google.com/citations?user=8sLL76sAAAAJ&hl=en>  
📄 <https://www.researchgate.net/profile/John-Morrissey-2>

## Employment History

- 2013–Pres.      📖 **Research Associate.** *Institute for Infrastructure & Environment, School of Engineering, University of Edinburgh, Edinburgh, United Kingdom.*  
Post doctoral researcher in the field of granular solids - modelling & experiments. Member of the Granular Mechanics & Industrial Infrastructure Research Group.
- DEM particle scale modelling and experimentation on particulate solid processes, with a focus on Model Driven Design for industrial applications.
  - Maintainer & main developer of **Edinburgh Elasto-Plastic Adhesion Model (EEPA)**
  - Maintainer & co-developer of **Edinburgh Timoshenko Beam Bond Model (ETBBM)**
  - Training in Upscaling particle Systems: Advancing Industry across Length-scales: TUSAIL. Horizon 2020 ITN.
  - Research collaboration with doctoral students
  - Co-supervision of M.Eng. and B.Eng. thesis students
- 📖 **Consultant.** *Edinburgh Innovations, Edinburgh, United Kingdom.*  
Consulting work in the specialised field of granular mechanics. Experimental characterisation, numerical simulation, calibration.
- **Altair EDEM:** Integration of EEPA model into EDEM; Feature upgrades for industrial solids modelling
  - **Various MNCs:** Development of digital models and digital twins for various industrial products and processes
- 2009–2014      📖 **Tutor & Demonstrator.** *Institute for Infrastructure & Environment, School of Engineering, University of Edinburgh, Edinburgh, United Kingdom.*  
**Subjects:** Soil Mechanics, Geotechnical Engineering, Computational Geomechanics.
- 2005–2006      📖 **Engineering Technician.** *MHL & Associates, Consulting Engineers, Douglas Rd., Cork, Ireland.*  
Responsibilities included liaising with clients, the preparation of technical drawings, design calculations and project documents.


## Education

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- 2009–2013     **Ph.D. in Civil Engineering, University of Edinburgh, United Kingdom.**  
**Thesis title:** *Discrete Element Modelling of iron ore pellets to include the effects of moisture and fines.*  
Thesis available at <http://www.era.lib.ed.ac.uk/handle/1842/8270>
- 2006–2009     **M.Eng. Civil Engineering, University of Edinburgh, United Kingdom.**  
First class honours.  
Final year Thesis title: *Evaluation of Ground Penetrating Radar (GPR) responses from full-scale model railway track under variable conditions.*
- 2003–2005     **B.Eng. (Ord) Civil Engineering, Cork Institute of Technology, Ireland.**  
*First Class Honours.*



## Teaching & Education Provision

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- 2013–Pres.     **Institute for Infrastructure & Environment, School of Engineering, University of Edinburgh, Edinburgh, United Kingdom.**  
Co-supervision of M.Eng. and B.Eng. thesis students:
  - 18 in total on topics such as numerical simulation of concrete, flexible barriers and high speed rail, material characterisation of cohesive powders.

## Research

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- 2013–Pres.     **DEM particle scale modelling and experimentation on particulate solid processes, with a focus on Model Driven Design for industrial applications.**
  - Previous projects include:
    - Models for Manufacturing of Particulate Products (CPI/UKRI)
    - VELaSSCo (EUPP7)
    - Handling and storing behaviour of iron ore fines (LKAB Minerals)
  - Maintainer & main developer of *Edinburgh Elasto-Plastic Adhesion Model (EEPA)*
  - Maintainer & co-developer of *Edinburgh Timoshenko Beam Bond Model (E-TBBM)*
- 2020–Pres.     **Training in Upscaling particle Systems: Advancing Industry across Length-scales: TUSAIL**  
Horizon 2020 ITN (16 academic and industrial partners led by the University of Edinburgh). My duties include:
  - Part of local Project Management Office coordinating the project
  - Involvement in data management and training aspects during the project.

## Research (continued)

- 2016–Pres.  **Collaboration with Zhejiang University, China** under the **Royal Society Newton Fellowship** .  
Research project to study the behaviour of *ballasted tracks* using *large scale DEM models* that are validated against full-scale experiments.  
Co-supervision of doctoral students:
- **Modelling of ballasted railways under high speed train loading.** - DEM models were coupled with rigid-body dynamics to simulate the effect of train loadings at various speeds. URL: <https://altairuniversity.com/51412-edem-research-spotlight-discrete-element-modeling-of-high-speed-railway-embankment/>
  - **Modelling of shear vane tests on Ningbo clay.** DEM models are used to investigate the key mechanisms of a soft clay. URL: <https://altairuniversity.com/51393-edem-research-spotlight-dem-modeling-of-soft-soil-based-on-the-edinburgh-elasto-plastic-frictional-contact-model/>
- 2018–2020  **Collaboration with Shandong University, China.** [Paused due to SARS-COV-2 Pandemic]  
Research project to study geohazards in the construction of tunnels in China.
- Co-organiser of international workshop **Discrete Methods in Geotechnical Engineering for Transportation** ([www.dmgt-2019.eng.ed.ac.uk/home](http://www.dmgt-2019.eng.ed.ac.uk/home))
  - Co-supervision of visiting doctoral students:
    - **Modelling soil erosion and the on-set of water and mud inrush during tunnelling through karst regions due to geological faults.** URL: <https://altairuniversity.com/51349-edem-research-spotlight-discrete-element-modelling-of-water-and-mud-inrush-hazards-in-tunnels/>
- 2017–2019  **Models for Manufacturing of Particulate Products.**  
My role as **RA** in this research project was to develop a generic framework that helps transfer state-of-the-art, multi-scale particle models for particulate systems from academia into industrial practice. This project was in collaboration with **University of Sheffield, Pfizer, Johnson-Matthey, AstraZeneca, P&G, CPI, PSE Ltd, DEM Solutions Ltd.**
- Developed DEM-PBM coupling framework for EDEM-gPROMS
  - Wet granulation exemplar study on Twin Screw Granulation
  - Joint author of best practice guide that describes a generic framework to enable industry to implement the best available models into industrial practice
- 2017–2018  **DEM simulation of agricultural materials. Collaboration with Budapest University of Technology and Economics, Hungary.**  
My role was co-supervision of visiting doctoral student:
- **DEM Simulation of Cutting of Corn Stalks** - Bonded DEM simulations were used to simulate the stalks of agricultural crops with the goal of improving harvester cutting design and efficiency

## Research (continued)

2016–2017

### Visualization for Extremely Large-Scale Scientific Computing - VELA<sup>SS</sup>Co.

URL: <https://github.com/velassco/VELASSCO>

A new platform was developed to provide *visual analysis methods* for large-scale simulations utilising *Big Data tools/architectures* to enable in-situ processing for analytics of engineering and scientific data. My role in the project was as **Principal Applications Engineer** to verify platform outputs and ensure optimal user experience.

2015–2016

### Knowledge Transfer Partnership

**Partners:** Freeman Technology, DuPont, The Chemours Company

The Edinburgh Powder Tester (EPT) is a successful *uniaxial tester* developed at the University of Edinburgh. My Role as **Principal RA** in this KTP project included:

- Generation of reference experimental data-set on EPT for verification purposes
- Transfer of key technologies to Freeman Technology design
- Several short-term secondments at Freeman Technology developing and testing of initial prototypes
- Led to licensing of the EPT technology to Freeman Technology as the Freeman Uniaxial Powder Tester (UPT)

2013–2015

### Handling and storing behaviour of iron ore fines.

In collaboration with LKAB plc, Sweden. My role as **Principal RA** was to further develop the EEPA contact model developed at the University of Edinburgh to study the effect of time and temperature on cohesive solids and incorporate such effects into DEM models.

## Research (continued)

### Conference Presentations

- 1 **Morrissey, J. P.** (2019d). *Investigating the effects of cohesion and screw configuration in a twin-screw granulator using the discrete element method*. 8th International Conference on Discrete Element Methods: DEM8, University of Twente, Netherlands.
- 2 **Morrissey, J. P.**, Ooi, J. Y., & Bian, X. (2019). *Dem particle scale modelling of a full scale ballasted rail track*. Discrete Methods in Geotechnical Engineering for Transportation (DMGT 2019). Retrieved from <https://www.dmgt-2019.eng.ed.ac.uk/home>
- 3 **Morrissey, J. P.** (2016b). *Dem particle scale modelling of a full scale ballasted rail track*. Invited Presentation at the 7th International Symposium on Environmental Vibration and Transportation Geodynamics held at Zhejiang University.
- 4 **Morrissey, J. P.** (2014a). *Effect of solid cohesion and friction on silo discharge*. Conference presentation at the 7th World Congress on Particle Technology (WCPT7), Beijing, China.
- 5 **Morrissey, J. P.** (2014b). *Measurement and prediction of compression and shear behavior of wet iron ore fines*. Conference presentation at the 7th World Congress on Particle Technology (WCPT7), Beijing, China.

## Knowledge Exchange & Impact

### ■ Numerous Consultancy projects with Various MNC's

Carried out numerous consultancy projects developing new technology and adapting existing technologies for clients needs.

- **Altair EDEM:** Feature and performance upgrades for EEPA model
- **Various MNCs:** Development of digital models and digital twins
- **Various MNCs:** Development of new modelling tools and processes

### ■ Development of uniaxial tester [Co-Licence holder]

The Edinburgh Powder Tester (EPT) was further developed in collaboration with several industrial companies *Freeman Technology, DuPont, The Chemours Company*. Freeman Technology have licensed the technology and the Freeman UPT tester was launched in 2017.

### ■ Development of EEPA adhesive contact model. [Principal Researcher]

**Key outcome:** DEM contact model developed during Ph.D., the Edinburgh Elasto-Plastic Adhesion Model (EEPA), was integrated into the popular commercial DEM software **EDEM** in 2018. EDEM is used by researchers at over 300 universities in more than 50 countries and by many international companies across various industries to model their industrial powders.

Current maintainer of model and responsible for bug-fixes, new features and performance enhancements.

## Leadership, Management & Citizenship

### ■ Co-organiser of the UK-China International Particle Technology Forum VII Conference

- Joint Secretary of the Organising Committee

### ■ Co-organiser of various workshops held at Edinburgh

- Discrete Methods in Geotechnical Engineering for Transportation (DMGT 2019)
- EDEM Powder Calibration Workshop
- EDEM Academic workshop

### ■ Journal Reviewer

Journals include: Granular Matter, Simulation, International Journal of Mineral Processing, Powder Technology, International Journal of Computational Methods, Minerals Engineering Comminution, Canadian Geotechnical Journal, Chemical Engineering Science, Computational Particle Mechanics

### ■ Other Roles

- Provide training to students and research group members on the use of EDEM & Iota Suite
- Provide training to students, staff and research group members on various experimental apparatus operated by the research group
- Created Granular Mechanics research group wiki

## Skills

Languages     ■ Fluent English speaker. Basic French.



Experimental     ■ Uniaxial, Direct Shear, Jenike Shear, Confined Compression, Triaxial, INSTRON,  $k_0$ .

## Skills (continued)

Coding	Python, C++, MATLAB, Julia, R.
Modelling	EDEM, LIGGGHTS, GiD, gSOLIDS, gFORMULATE, Multi-body Dynamics, Coupled Problems, abaqus.
CAD	AutocAD, Solid Edge, GiD.
Data Analysis	Particle Analytics, Iota-Suite, paraview, GiD.
Web Dev	HTML, CSS
Misc.	Teaching, MS Office (Word, Powerpoint, Excel), L <sup>A</sup> T <sub>E</sub> X typesetting and publishing.

## Miscellaneous Experience

### Awards and Achievements

- 2008  **Rushlight Award** for Hydropower, Institute for Infrastructure and Environment, University of Edinburgh, United Kingdom.
-  **William Dudgeon Scholarship for Academic Achievement**, Institute for Infrastructure and Environment, University of Edinburgh, United Kingdom.

## External Recognition / Esteem

### Invited Talks & Lectures

- Morrissey, J. P.** (2019a). *Boundary conditions and machine interactions: Overlooked aspects of a simulation*. Presentation at: UK-China International Particle Technology Forum VII. Keynote Speaker. Edinburgh, UK.
- Morrissey, J. P.** (2019c). *Model driven design in particulate products manufacturing*. Presentation at: Integrated Control in Powder Formulations, CPI National Formulation Centre. Invited Speaker. Sedgefield, UK. Retrieved from <https://www.uk-cpi.com/events/integrated-control-in-powder-formulations>
- Morrissey, J. P.**, Wang, L. G., Ooi, J. Y., & Litster, J. D. (2019). *Model driven design in particulate products manufacturing workshop*. Presentation at: International Fine Particle Research Institute Winter Business Meeting. Invited Speaker. Van der Valk Hotel Schipol Airport, Amsterdam, Netherlands.
- Morrissey, J. P.** (2018c). *Models for manufacturing of particulate products project dissemination*. Presentation at: EDEM's "DEM Powder Calibration Meeting". Invited Speaker. Edinburgh, UK.
- Morrissey, J. P.** (2017). *Dem modelling of cohesionless, cohesive and cementitious materials*. Invited Lecture at the Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan. Retrieved from [http://www.whrsm.cas.cn/xwdt2020/xsjl\\_168100/202007/t20200718\\_5634549.html](http://www.whrsm.cas.cn/xwdt2020/xsjl_168100/202007/t20200718_5634549.html)
- Morrissey, J. P.** (2016a). *Beyond basic: Advanced simulations in edem using the application programming and coupling interfaces*. Presentation at: EDEM Academic Workshop. Invited Speaker. Edinburgh, UK.

## Research Publications

### Journal Articles

- Chen, X., Peng, D., **Morrissey, J. P.**, & Ooi, J. Y. (2022). \*A comparative assessment and unification of bond models in DEM simulations. *Granular Matter*, 24(29). [doi:10.1007/s10035-021-01187-2](https://doi.org/10.1007/s10035-021-01187-2)



- 2 Chen, X., Wang, L. G., **Morrissey, J. P.**, & Ooi, J. Y. (2022). DEM simulations of agglomerates impact breakage using Timoshenko beam bond model [Under Review]. *Granular Matter*.
- 3 Gu, Q., Zhao, C., Bian, X., **Morrissey, J. P.**, & Ooi, J. Y. (2021). Trackbed settlement and associated ballast degradation due to repeated train moving loads [in press]. *Soil Dynamics and Earthquake Engineering*. [doi:10.1016/j.soildyn.2021.107109](https://doi.org/10.1016/j.soildyn.2021.107109)
- 4 **Morrissey, J. P.**, Hanley, K. J., & Ooi, J. Y. (2021). Conceptualisation of an efficient particle-based simulation of a twin-screw granulator. *Pharmaceutics*, 13(12). [doi:10.3390/pharmaceutics13122136](https://doi.org/10.3390/pharmaceutics13122136)
- 5 Wang, L. G., **Morrissey, J. P.**, Barrasso, D., Slade, D., Clifford, S., Reynolds, G., ... Litster, J. D. (2021). \*Model driven design for twin screw granulation using mechanistic-based population balance model. *International Journal of Pharmaceutics*, 607, 120939. [My significant contribution to this work is the model drive design framework.] [doi:10.1016/j.ijpharm.2021.120939](https://doi.org/10.1016/j.ijpharm.2021.120939)
- 6 **Morrissey, J. P.**, Totoo, P., Hanley, K. J., Papanicolopoulos, S.-A., Ooi, J. Y., Gonzalez, I. C., ... Gierlinger, T. (2020). Post-processing and visualization of large-scale DEM simulation data with the open-source VELA SCo platform. *Simulation*, 96(7), 567–581. [doi:10.1177/0037549720906465](https://doi.org/10.1177/0037549720906465)
- 7 De Bold, R., O'Connor, G., **Morrissey, J. P.**, & Forde, M. C. (2015). \*Benchmarking large scale GPR experiments on railway ballast. *Construction and Building Materials*, 92, 31–42. [doi:10.1016/j.conbuildmat.2014.09.036](https://doi.org/10.1016/j.conbuildmat.2014.09.036)
- 8 Thakur, S. C., **Morrissey, J. P.**, Sun, J., Chen, J. F., & Ooi, J. Y. (2014). \*Micromechanical analysis of cohesive granular materials using discrete element method with an adhesive elasto-plastic contact model. *Granular Matter*, 16(3), 383–400. [Joint Authorship]. [doi:10.1007/s10035-014-0506-4](https://doi.org/10.1007/s10035-014-0506-4)

## Books and Chapters

- 1 Ooi, J. Y., Zhu, Q., Ocone, R., Fan, X., **Morrissey, J. P.**, & Karatza, Z. (Eds.). (2019). *Proceedings of the 7th UK–China International Particle Technology Forum*, Edinburgh, UK: School of Engineering, University of Edinburgh, 258.
- 2 Gu, Q., Bian, X., & **Morrissey, J. P.** (2018). Dem simulation of simplified railway embankment under the effect of train-induced dynamic load. In X. Bian, Y. Chen, & X. Ye (Eds.), *Environmental vibrations and transportation geodynamics* (pp. 423–431). [doi:10.1007/978-981-10-4508-0\\_39](https://doi.org/10.1007/978-981-10-4508-0_39)

## Conference Proceedings

- 1 Pantaleev, S., **Morrissey, J. P.**, & Ooi, J. Y. (2019). An experimentally validated DEM simulation of a monotonic triaxial test on railway ballast including the membrane boundary condition. In J. Y. Ooi, Q. Zhu, R. Ocone, X. Fan, J. P. Morrissey, & Z. Karatza (Eds.), *Proceedings of the 7th uk–china international particle technology forum* (p. 2). Edinburgh, UK: The University of Edinburgh.
- 2 Wang, L. G., **Morrissey, J. P.**, Ooi, J. Y., Litster, J. D., & Slade, D. (2019). Application of Digital Twin in the Particulate Process: Impact Pin Mill and Twin Screw Granulation. In J. Y. Ooi, Q. Zhu, R. Ocone, X. Fan, J. P. Morrissey, & Z. Karatza (Eds.), *Proceedings of the 7th uk–china international particle technology forum* (p. 2). Edinburgh, UK: The University of Edinburgh.
- 3 Khan, H., **Morrissey, J. P.**, Ooi, J. Y., & Tod Pittam, J. (2015). A discrete element analysis of the micromechanical interaction of non-spherical particles in cohesionless granular solids under Ko condition. In *Geomechanics from micro to macro - proceedings of the tc105 issmge international symposium on geomechanics from micro to macro, is-cambridge 2014* (Vol. 1).
- 4 **Morrissey, J. P.**, Ooi, J. Y., & Chen, J. F. (2014). Effect of Solid Cohesion and Friction on Silo Discharge. In *7th world congress on particle technology (wcpt7)* (p. 8). Beijing, China.

- 5 **Morrissey, J. P.**, Ooi, J. Y., Chen, J. F., Tano, K. T., & Horrigmoe, G. (2014). Measurement and prediction of compression and shear behavior of wet iron ore fines. In *7th world congress on particle technology (wcpt7)* (p. 8). Beijing, China.
- 6 **Morrissey, J. P.**, Ooi, J. Y., & Chen, J. F. (2013). A DEM study of silo discharge of a cohesive solid. In M. Bischoff, E. Ramm, E. Oñate, R. Owen, & P. Wriggers (Eds.), *Particle-based methods iii fundamentals and applications - particles 2013* (pp. 298–309). Stuttgart, Germany: International Center for Numerical Methods in Engineering (CIMNE).
- 7 **Morrissey, J. P.**, Ooi, J. Y., Chen, J. F., Tano, K. T., & Horrigmoe, G. (2013). Experimental and discrete element modelling of cohesive iron ore fines. In M. Bischoff, E. Ramm, E. Oñate, R. Owen, & P. Wriggers (Eds.), *Particle-based methods iii fundamentals and applications - particles 2013* (pp. 224–235). Stuttgart, Germany: International Center for Numerical Methods in Engineering (CIMNE).
- 8 **Morrissey, J. P.**, Ooi, J. Y., Chen, J. F., Tano, K. T., & Horrigmoe, G. (2012). An Experimental and DEM Study of the Behaviour of Iron Ore Fines. In *7th international conference for conveying and handling of particulate solids - chops 2012* (pp. 1–10). Friedrichshafen, Germany. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84897750667%7B%5C%7DpartnerID=MN8TOARS>
- 9 Thakur, S. C., **Morrissey, J. P.**, Sun, J., Chen, J., & Ooi, J. Y. (2012). Discrete element modelling of cohesive bulk materials. In *7th international conference for conveying and handling of particulate solids, chops 2012*.
- 10 **Morrissey, J. P.**, Thakur, S. C., Sun, J., Chen, J.-F. F., & Ooi, J. Y. (2011). Modelling Cohesive-Frictional Particulate Solids For Bulk Handling Applications. In E. Oñate & D. Owen (Eds.), *li international conference on particle-based methods – fundamentals and applications - particles 2011* (pp. 1–11). International Center for Numerical Methods in Engineering (CIMNE). Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84860226972%7B%5C%7DpartnerID=MN8TOARS>
- 11 Thakur, S. C., **Morrissey, J. P.**, Sun, J., Chen, J. F., & Ooi, J. Y. (2011). A DEM study of cohesive particulate solids: plasticity and stress- history dependency. In *11th particulate systems analysis conference: Psa 2011* (pp. 1–5). Edinburgh, UK: International Center for Numerical Methods in Engineering (CIMNE).
- 12 De Bold, R., O'Connor, G., **Morrissey, J. P.**, & Forde, M. C. (2010). New analysis of ground penetrating radar testing of a mixed railway trackbed. In *Proceedings of the transportation research board 89th annual meeting*. Transportation Research Board, 500 Fifth Street, NW, Washington, DC United States 20001: Transportation Research Board.

## Reference Documents

- 1 Brown, N. J., **Morrissey, J. P.**, Ooi, J. Y., & Chen, J.-F. (2014a). *EDEM Contact Model: Timoshenko Beam Bond Model*. University of Edinburgh. [doi:10.13140/RG.2.2.16409.03689/1](https://doi.org/10.13140/RG.2.2.16409.03689/1)
- 2 Brown, N. J., **Morrissey, J. P.**, Ooi, J. Y., & Chen, J.-F. (2014b). *Using the Timoshenko Beam Bond Model: Example Problem*. University of Edinburgh. [doi:10.13140/RG.2.2.30271.84641](https://doi.org/10.13140/RG.2.2.30271.84641)
- 3 **Morrissey, J. P.**, Thakur, S., & Ooi, J. Y. (2014a). *EDEM Contact Model: Adhesive Elasto-Plastic Model*. University of Edinburgh. [doi:10.13140/RG.2.2.10139.18724](https://doi.org/10.13140/RG.2.2.10139.18724)
- 4 **Morrissey, J. P.**, Thakur, S., & Ooi, J. Y. (2014b). *Using the Elasto-plastic Adhesion Model: Example Problem*. University of Edinburgh. [doi:10.13140/RG.2.2.10978.04809](https://doi.org/10.13140/RG.2.2.10978.04809)

## Conference Posters



- 1 **Morrissey, J. P.** (2019b). Multiscale modelling of a twin screw granulator [poster presentation]. Poster. Poster presented at: Royal Society of Chemistry Formative Formulation Workshop, Maxwell Centre, University of Cambridge. [doi:10.13140/RG.2.2.35252.58240](https://doi.org/10.13140/RG.2.2.35252.58240)
- 2 **Morrissey, J. P.** (2018a). Hybrid multiscale modelling of a twin screw granulator. Poster. Presented at: 8th World Congress on Particle Technology. [doi:10.13140/RG.2.2.16645.17123/1](https://doi.org/10.13140/RG.2.2.16645.17123/1)
- 3 **Morrissey, J. P.** (2018b). Modelling a twin screw granulator using the discrete element method [poster presentation]. Poster. Presented at: 8th World Congress on Particle Technology. [doi:10.13140/RG.2.2.18480.17926](https://doi.org/10.13140/RG.2.2.18480.17926)
- 4 Filippone, G., Janda, A., Totoo, P., **Morrissey, J. P.**, Hanley, K., Papanicolopoulos, S., ... Liestøl, O. (2016). The velasco framework: A software platform for end-user analytics and visualization of large simulation datasets. Poster. Presented at: PARTEC 2016: International Congress on Particle Technology. [doi:10.13140/RG.2.2.20556.13446](https://doi.org/10.13140/RG.2.2.20556.13446)
- 5 **Morrissey, J. P.** (2013a). Dealing with a sticky situation: Modelling cohesive frictional granular solids [poster presentation]. Poster. Poster presented at: Telford-UKIERI workshop on Anisotropic, heterogeneous and cellular materials: From microarchitecture to macro-level response, Edinburgh, UK. [doi:10.13140/RG.2.2.35676.82568](https://doi.org/10.13140/RG.2.2.35676.82568)