Cite this article
Barreto D, Ciantia MO and Osman A (2021)
Editorial.
Proceedings of the Institution of Civil Engineers – Geotechnical Engineering **174(5)**: 473–475,
https://doi.org/10.1680/jgeen.2021.174.5.473

Editorial

Geotechnical Engineering

ICE Publishing

Editorial

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Computational power has reached levels that may have been difficult to imagine a decade ago. Simultaneously, our knowledge of ground behaviour has significantly increased. Arguably, the prediction of geotechnical failures is now straightforward, whether that is via empirical predictions, limit equilibrium approaches or conventional numerical analyses. Technological advances and more complex geotechnical applications have derived the need to further understand large-strain deformation and hence the numerical tools to do so. As a journal with a particular focus on industrial applications, the objective of this themed issue on numerical modelling of large-strain deformation in geotechnical engineering is to help disseminate how recently developed tools may be used to tackle difficult, albeit realistic problems. As such, this issue spans the use of numerical techniques (from modified finite difference method formulations and discrete element approaches to sophisticated material point method implementations), as well as a wide range of problems (from pore water dissipation under vacuum consolidation to offshore applications, the post-failure deformation of slopes including unsaturated soil mechanics and earthquake effect as well as several practical design applications using discrete element methods). All the articles comprising this issue have common ground in tackling large-scale boundary value problems that were intractable not long ago, particularly when particle-based methods are considered. However, they also share the presence of many unanswered questions. For example, the need for more advanced constitutive contact relationships for MPM modelling of earthquake-triggered landslides (Alsardi *et al.*, 2021) or the full effect of impact driving on the behaviour of offshore piles under lateral loads (Bienen *et al.*, 2021). We expect, however, these questions to be solved relatively soon.

The article by Wang *et al.* (2021) uses the most conventional approach, a modified finite difference scheme to quantify excess pore water pressure dissipation and large-strain consolidation of dredged clays under vacuum pressure. The model includes vacuum pressure growth pressure propagation and non-linear compressibility and permeability relationships and may be used to provide a technical specification for drainage design, settlement control, amongst others.

The following three articles by Li *et al.* (2021), Previtali *et al.* (2021) and Sharif *et al.* (2021) use the Discrete Element Method (DEM) to study significant boundary value problems. First, Li *et al.* (2021) deal with dynamic compaction by comparing the crater depths generated using DEM simulations of equivalent 50 g centrifuge tests. The numerical results match the experimental ones reasonably well but do involve particle scaling to reduce the computational cost, and they did require the use of damping coefficients and other non fully physical assumptions to provide a reasonable match. Previtali *et al.* (2021) provided a study on the behaviour of rockfall fence nets that nicely demonstrates that DEM may be used to identify critical scenarios and mitigate failure risk (see Figure 1). Sharif *et al.* (2021) also use DEM but deal with the geometry of offshore screw piles, their effect on installation, and their tensile and compressive resistance after installation. They find that pile geometry has different effects on the reduction of installation requirements (i.e. compressive force and torque) and tensile and compressive resistance. As a result of the (still) large computational expense for DEM studies, all these studies consider unrealistic particle shapes (spheres), but this does not detract from the benefits they provide in terms of further understanding of particle-scale interactions and their effect on observed macro-scale behaviour.

Bienen *et al.* (2021) also considered installation effects on piles. They, however, considered open-ended piles for offshore wind

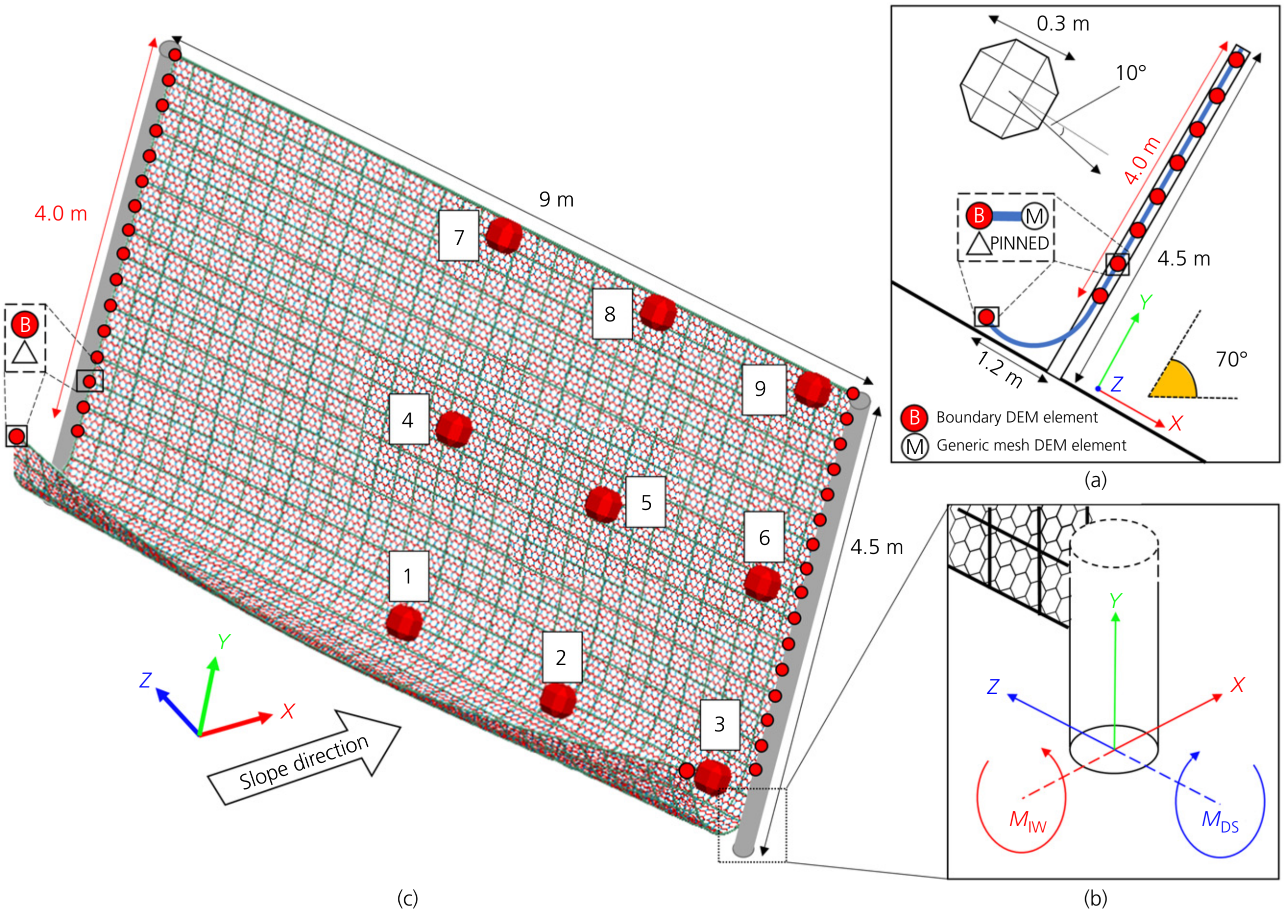
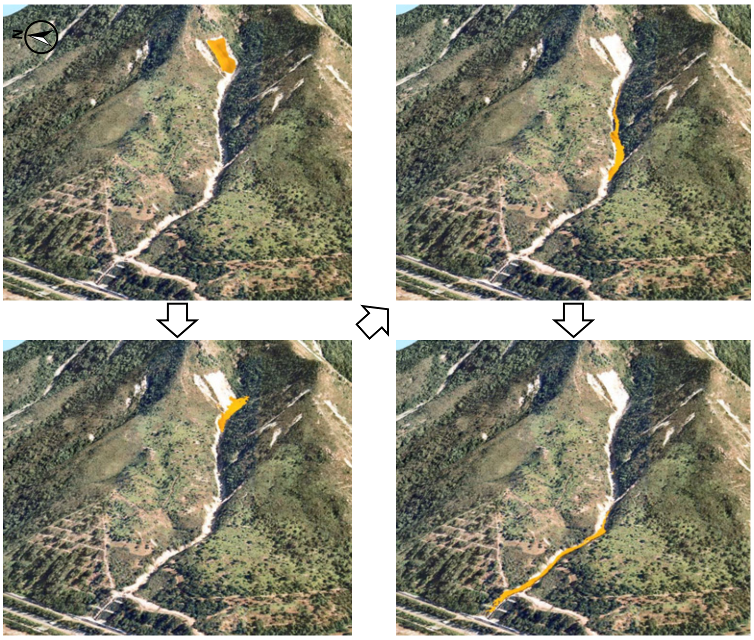


Figure 1. DEM simulation of rockfall fence protection showing different boulder impact positions that were analysed (Previtali *et al.*, 2021: p. 500)

turbines and used the Coupled Eulerian-Lagrange (CEL) method for their numerical analyses. Their results compare results from simulations with wished-in-place, jacked and impact-driven piles and conclude that installation effects are significant on lateral pile capacity. This is particularly important in the case of impact-driven piles (as it happens in the field), but they highlight that due to computational cost, their analyses only consider impact driving at the late stage of the installation process and therefore, findings are only indicative. The offshore theme continues with the work by Xu *et al.* (2021), who also use CEL to quantify the model uncertainty of ISO methods for the punch-through capacity of spudcan foundations. The paper highlights that apart from providing good estimations, the CEL method enables modification of existing ISO methods by considering the systematic part of model uncertainties.

The next two articles of the issue are based on the material point method (MPM) to analyse the runout from earthquake-triggered landslides (Alsardi *et al.*, 2021) and the deformation of water retention structures considering unsaturated soil mechanics (Gorari *et al.*, 2021). The work by Gorari *et al.* (2021) proposes a novel single-point two-phase MPM formulation for the analysis of unsaturated soil behaviour subjected to transient hydraulic boundary conditions. Their MPM results compare well with finite element and limit equilibrium methods at small strains but also provide interesting insights into the post-failure deformation mechanisms, which are also compared against experiments of a large-scale slope collapse. The work by Alsardi *et al.* (2021) proposes a novel approach that avoids noise generation due to cell-crossing of material points to analyse the behaviour of earthquake-triggered landslides. The magnitude of landslide runout from their results matches well with those obtained with finite element and finite difference methods and empirical Newmark-type approaches. However they also highlight that their method cannot provide a great match with regards to crest scarp, being the result of the continuum nature of MPM and suggest that this may be improved with more advanced constitutive contact relationships. In hindsight, as editors, we may argue that this could also be possible by a combination of the numerical methods discussed in this themed issue.



(b)

Figure 2. b) Landslide animation as a result of integrating GIS and advanced large-strain numerical analysis of debris flows (Kwan *et al.*, 2021: p. 606)

Regarding a combination of numerical methods, the contribution by Kwan *et al.* (2021) closes this themed issue in a spectacular manner. With the emphasis on Hong Kong experience and case studies, their review highlights how the modelling of debris flows for landslide risk assessment has progressed. They start by discussing empirical and 2D finite-difference models that progress into 3D dynamic analysis using particle-in-cell (PIC) methods akin to MPM methods and Arbitrary Lagrangian-Eulerian (ALE) finite element methods that enable the coupled analysis of debris dynamics and structural responses to facilitate optimisation of mitigation methods. Further, they discuss how practitioners have successfully used these methods, including recent enhancements, by integrating geographic information systems and their coupled FE analyses (see Figure 2).

REFERENCES

Alsardi A, Copana J and Yerro A (2021) Modelling earthquake-triggered landslide runout with the material point method. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 563–576, https://doi.org/10.1680/jgeen.20.00235.

Bienen B, Fan S, Schröder M and Randolph MF (2021) Effect of the installation process on monopile lateral response. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 530–548, https://doi.org/10.1680/jgeen.20.00219.

Girardi V, Yerro A, Ceccato F and Simonini P (2021) Modelling deformations in water retention structures with unsaturated material point method. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 577–592, https://doi.org/10.1680/jgeen.21.00059.

Kwan JSH, Sze EHY, Lam C, Law RPH and Koo RCH (2021) Development and applications of debris mobility models in Hong Kong. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 593–610, https://doi.org/10.1680/jgeen.21.00008.

Li Y, Zhang J, Chen J, Chen X and Zhang W (2021) A micro study on centrifuge model test of dynamic compaction using discrete-element method. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 488–497, https://doi.org/10.1680/jgeen.20.00233.

Previtali M, Ciantia MO, Spadea S, Castellanza RP and Crosta GB (2021) Multiscale modelling of dynamic impact on highly deformable compound rockfall fence nets. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 498–511, https://doi.org/10.1680/jgeen.21.00108.

Sharif YU, Brown MJ, Ciantia MO *et al.* (2021) Assessing single-helix screw pile geometry on offshore installation and axial capacity. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 512–529, https://doi.org/10.1680/jgeen.21.00104.

Wang JH, Zeng LL, Ding JW and Hong ZS (2021) A large-strain consolidation model incorporating vacuum pressure growth propagation. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 476–487, https://doi.org/10.1680/jgeen.20.00166.

Xu SJ, Yi JT, Zhang TB, Wang Z and Yao K (2021) Characterising the model uncertainty of ISO methods for punch-through capacity prediction. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering* **174(5)**: 549–562, https://doi.org/10.1680/jgeen.21.00003.