Software for aiding design of screw pile for offshore wind turbine foundations

Lei Wang (lei.wang@durham.ac.uk)

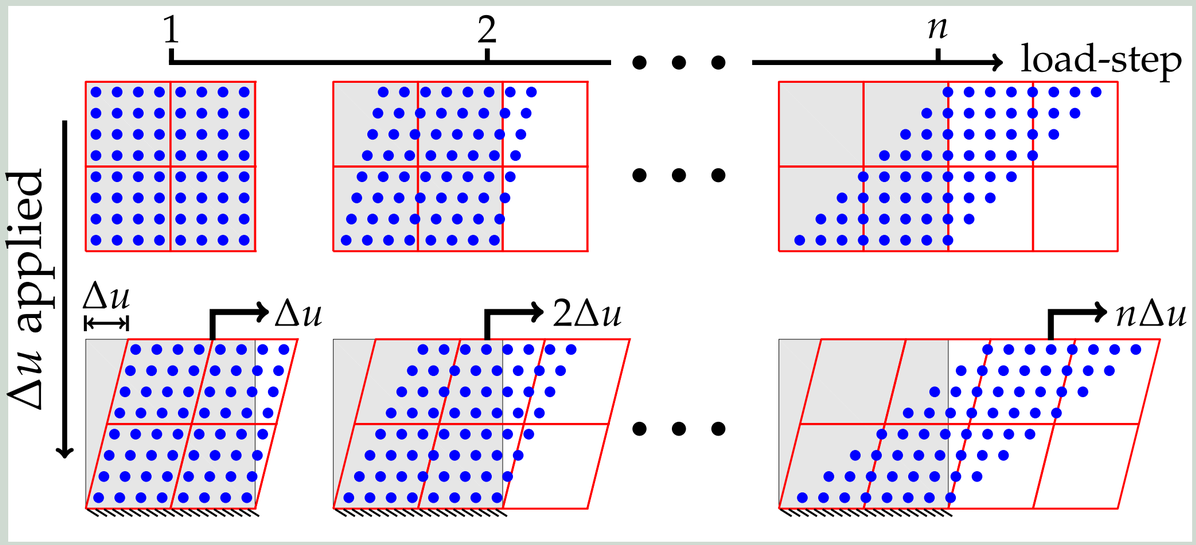
Department of Engineering, Durham University, Durham

Research background and aims

As part of the EPSRC funded Supergen Wind Grand Challenge project on designing screw piles for offshore wind turbine foundations, we are developing software for simulating the installation of screw piles. This software will be a useful computer-aided design tool for geotechnical engineers in understanding the impact of the geometry of the screw pile (length, diameter, flight spacing and size, etc.) on the installation torque and long term performance of the pile foundation in different seabed conditions.

The Material Point Method

The Material Point Method (MPM) is selected, because in general the MPM performs well for modelling very large deformations as compared to other methods, e.g. the Finite Element Method (FEM).



Demonstration of MPM modelling for a simple shear problem: high quality of computational mesh is maintained, implying high accuracy of results, while the material points handle historical deformation.

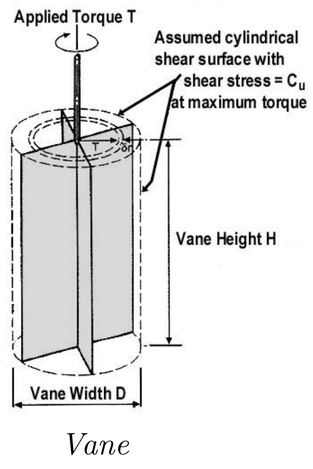
My contributions

Several strategies for accuracy and efficiency were implemented, e.g.

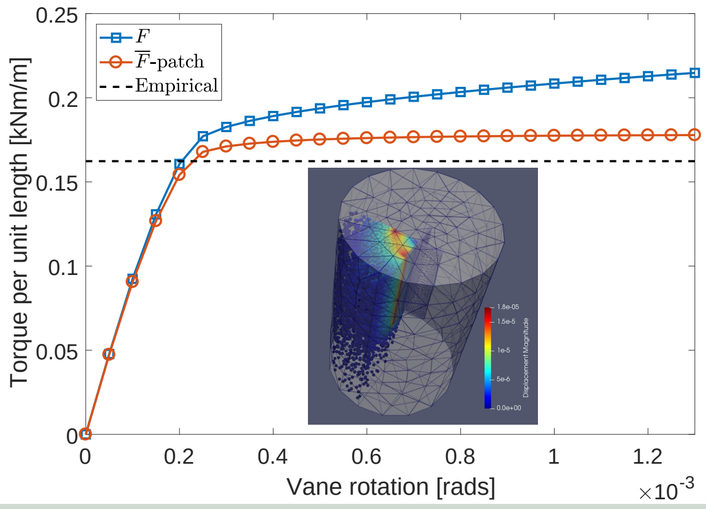
- modified the fundamental kinematic variable–deformation gradient, $\mathbf{F}$, to a variable–$\overline{\mathbf{F}}$-patch, which enables accurate description of the incompressible plastic deformation,
- integrated the fastest algorithm of searching material points in an unstructured mesh–walking a triangulation algorithm.

Verification

The correct torque can be obtained for the vane shear test, a standard geotechnical test involving large rotational deformation, with the $\overline{\mathbf{F}}$-patch method.

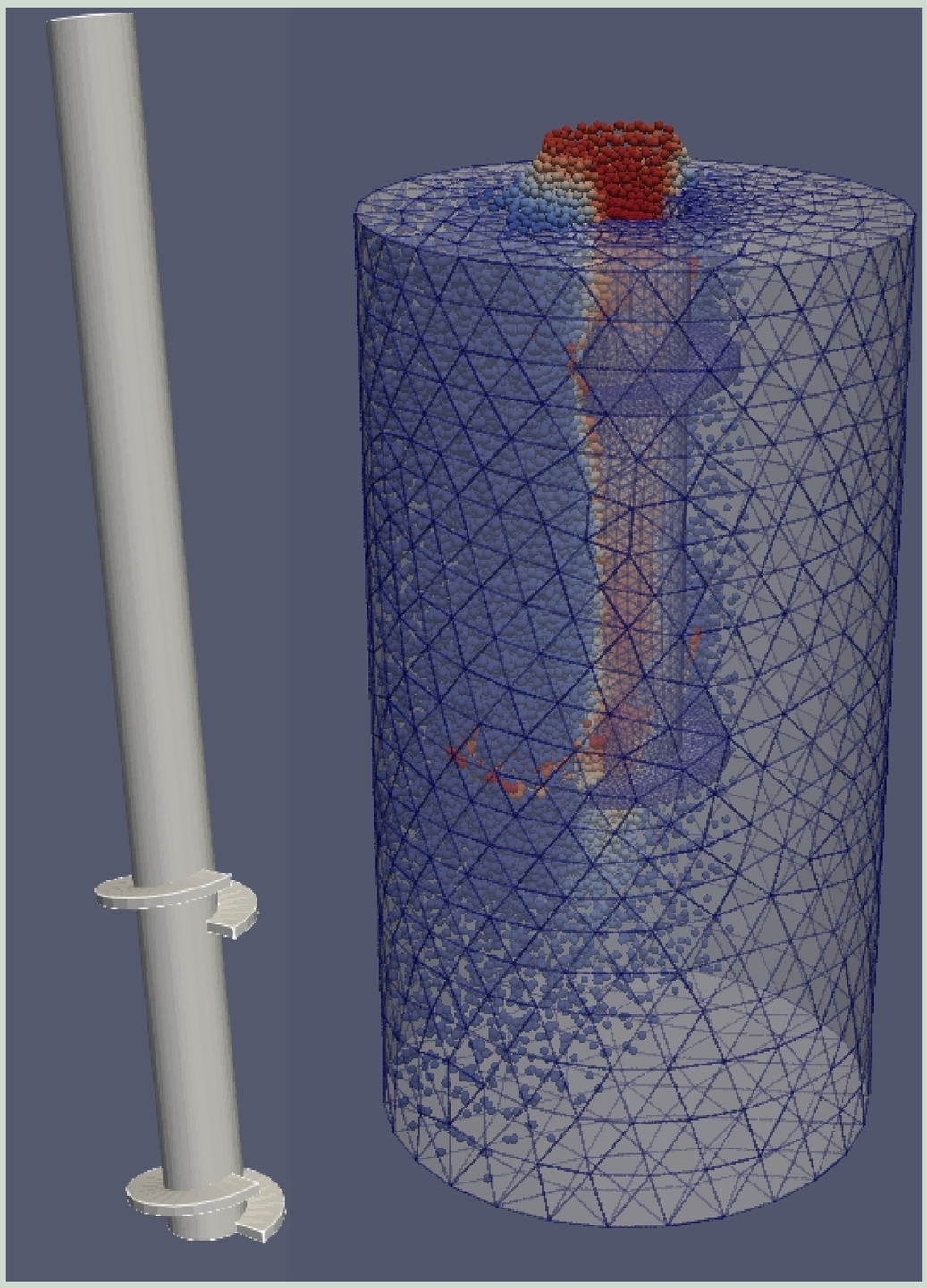


Vane

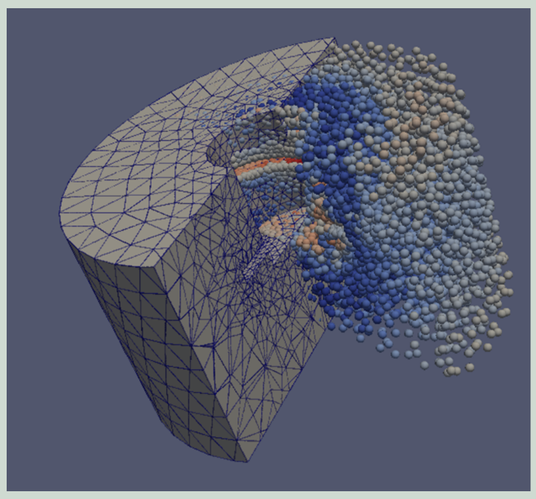


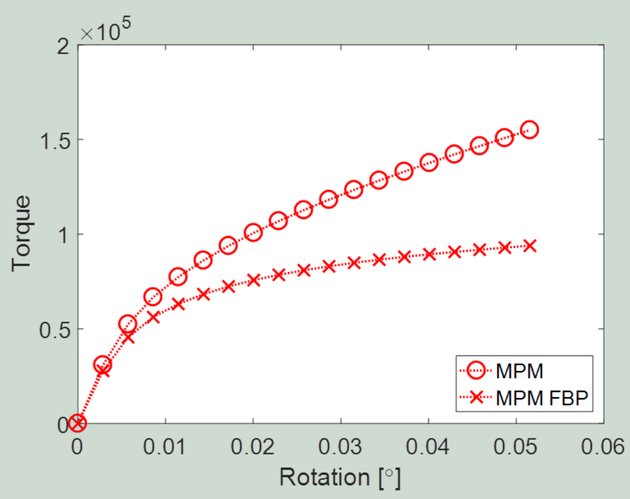
Applications

Example 1: the pull-out of a model screw-pile matching experimental work at Dundee University.



Example 2: the rotation of the partial screw-pile was simulated and the torque was computed. The torque from $\overline{\mathbf{F}}$-patch method (MPM FBP) is more physically correct than from the standard MPM, because it is consistent to the material elasto-plasticity.





Conclusions

- MPM software for 3D analysis of geotechnical problems has been developed and verified.
- This software is undergoing optimization, and parallelization for accelerating simulations.

Acknowledgement: Supervision of Prof Charles Augarde and Dr Will Coombs at Durham. Support from collaborators at Dundee and Southampton Universities. Funding from the EPSRC (No. EP/N006054/1).