Numerical modelling of screw pile installation for wind energy foundation systems

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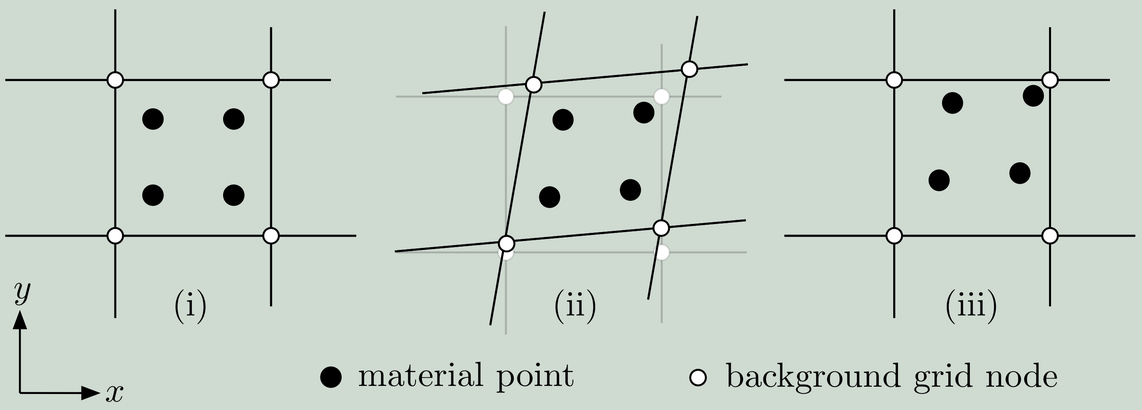
Computational geomechanics

- Computational geomechanics problems typically contain very large deformations, highly non-linear material behaviour and are often truly three-dimensional; challenging problems to tackle with numerical methods.
- The finite-element method is the *de facto* numerical simulation tool used in engineering however, it struggles to cope with very large deformations and/or fracture.
- The Material Point Method (MPM) is an alternative method that has the potential to be successful in these areas.

Material Point Method (MPM)

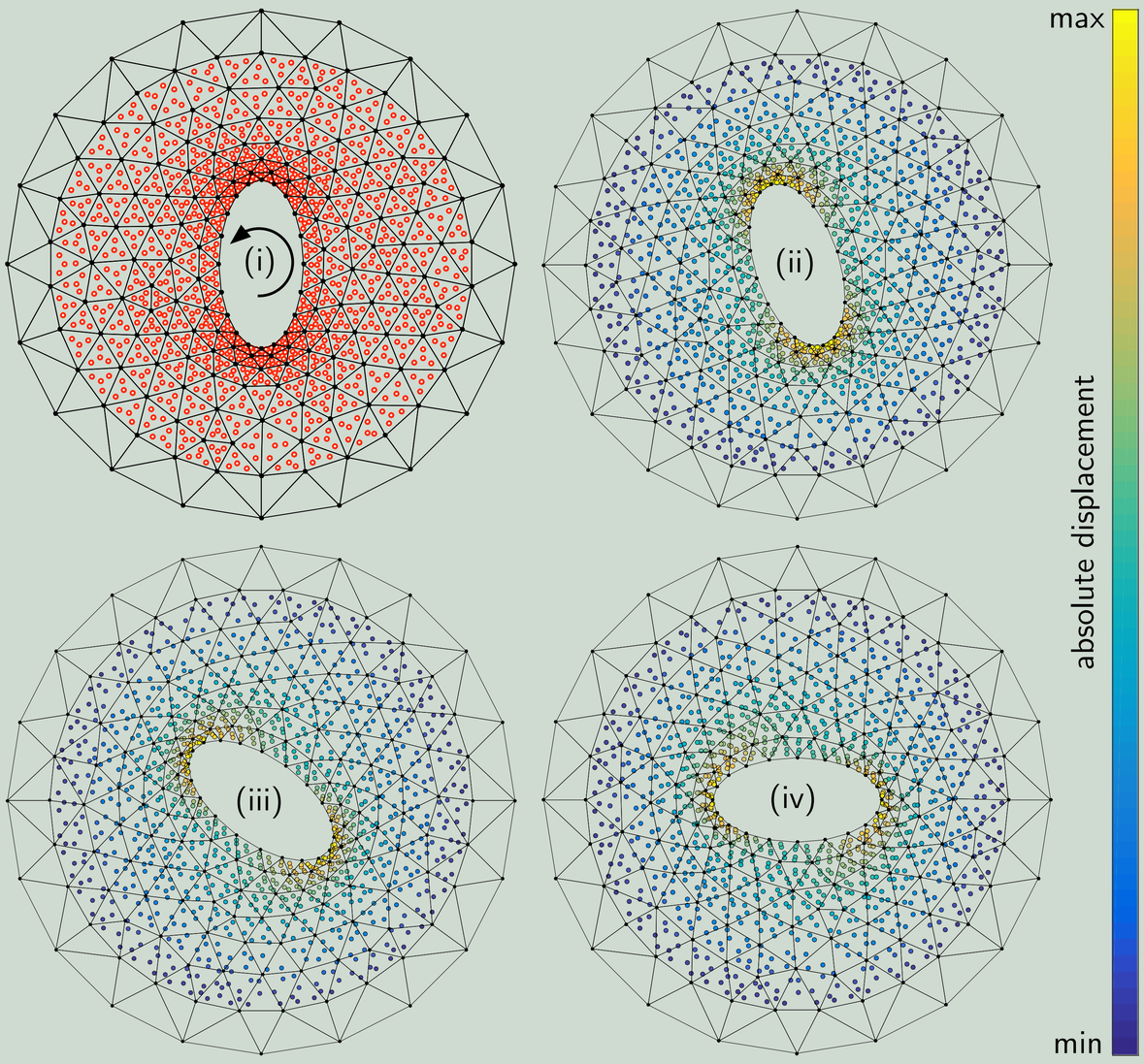
- Physical domain is represented by a series of points (material points).
- Numerical calculations performed on a regular background grid.
- Physical information (stress, strain, etc.) stored and carried at the material points and mapped to the background grid.



MPM numerical steps: (i) transfer information to the grid; (ii) calculate displacements & map to points; and (iii) reset grid & continue.

Moving mesh concept

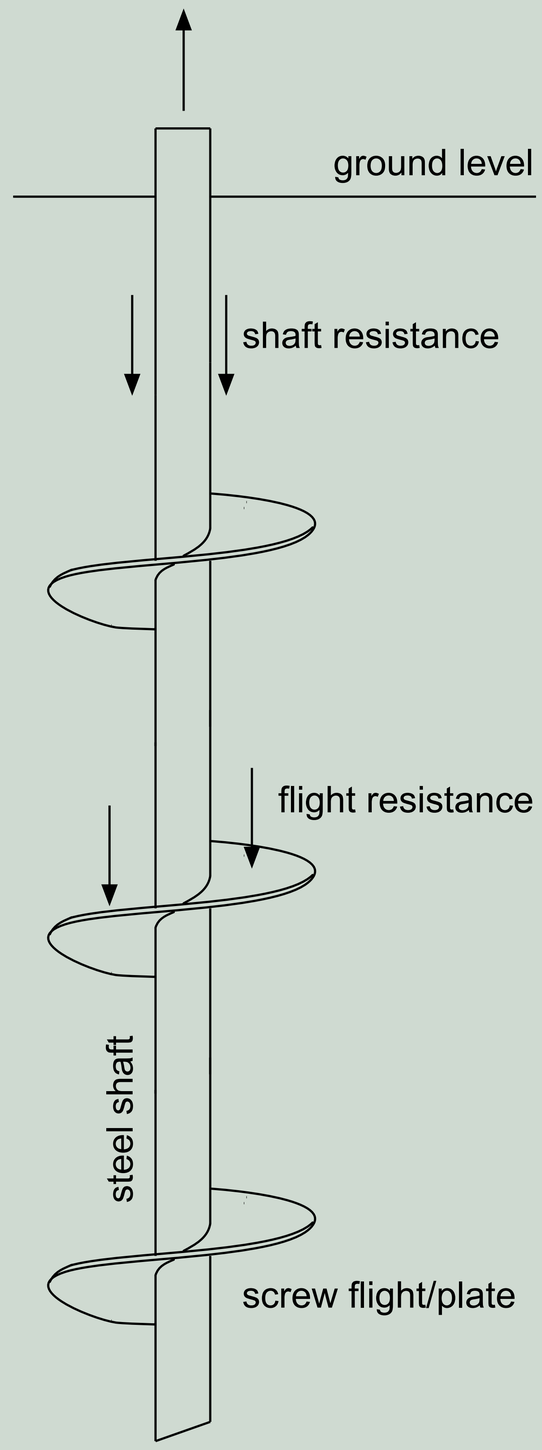
- Imposing boundary conditions (fixed displacements) that do not coincide with the background grid is challenging in the MPM.
- One method to overcome this when a rigid body is moving into a softer domain is the "moving mesh" concept.
- The mesh is *attached* to the moving body, the pile in this case, whilst remaining independent of the movement of the soil.
- Allows standard imposition of boundary conditions.
- For screw piles the body needs to rotate as well as translate.



2D MPM rotating mesh simulation: (i) initial setup showing grid (black lines) and material points (red circles), (ii) $18°$, (iii) $54°$ & (iv) $90°$ rotation

Screw pile installation

- Screw piles are foundations which are screwed into the ground and are widely used onshore, one example being to support motorway signs and gantries:
  - however, they have yet to be proved as an offshore renewable foundation system; and
  - due to 2050 energy targets the UK needs commercially viable wind turbine foundation solutions in deeper waters.



screw pile installation & load-resistance components

- Very challenging problem to model numerically due to:
  (i) very large deformations, (ii) non-linear material behaviour,
  (iii) truly three-dimensional and (iv) complex soil-structure interactions.

Installed capacity

- Soils *remember* what has happened to them - modelling the installation is key in understanding the disturbed *state* of the soil after pile installation.
- Disturbing the soil can significantly change the load-displacement response and capacity of installed pile.
- MPM results will be mapped to conventional finite element-based analysis for long term cyclic capacity.
- **Want to know more?**
  gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/N006054/1

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