

Multi-scale Numerical Modelling of Excavation Support Fluids

Yongxin Wang¹, Si Suo^{1,2}, Catherine O'Sullivan¹, and Martin J Blunt²

¹Department of Civil and Environmental Engineering, Imperial College London. ²Department of Earth Science & Engineering, Imperial College London.

Funders:



EPSRC

Engineering and Physical Sciences Research Council

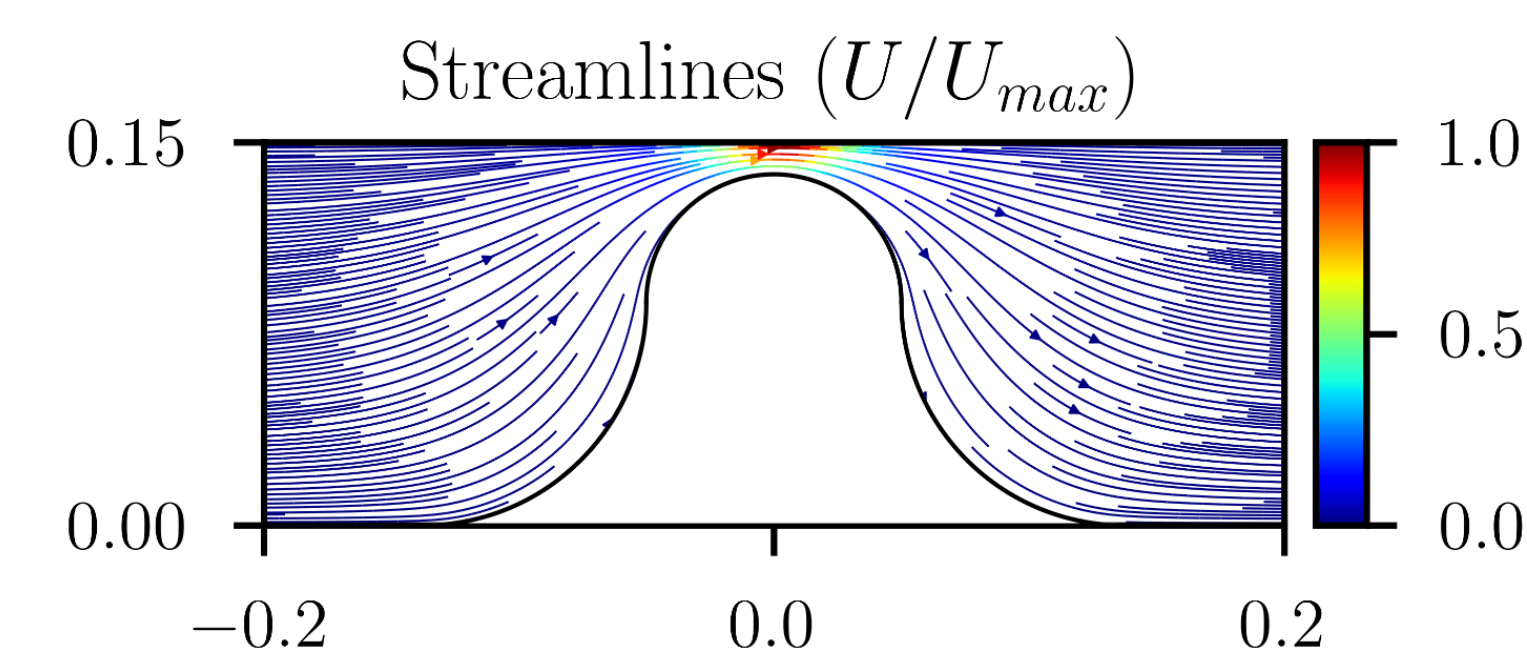
Motivation: Support fluids are used to keep excavations open for underground construction. Polymer fluids (suspensions of polymer in water) have significant advantages over more conventional bentonite suspensions. Polymer fluids are non-Newtonian fluids and so the conventional modelling tools used in geotechnical engineering cannot be employed to predict their behaviour. This has hindered their use in UK ground engineering. We have used a multi-scale modelling approach to answer key questions posed about these fluids by the construction industry.



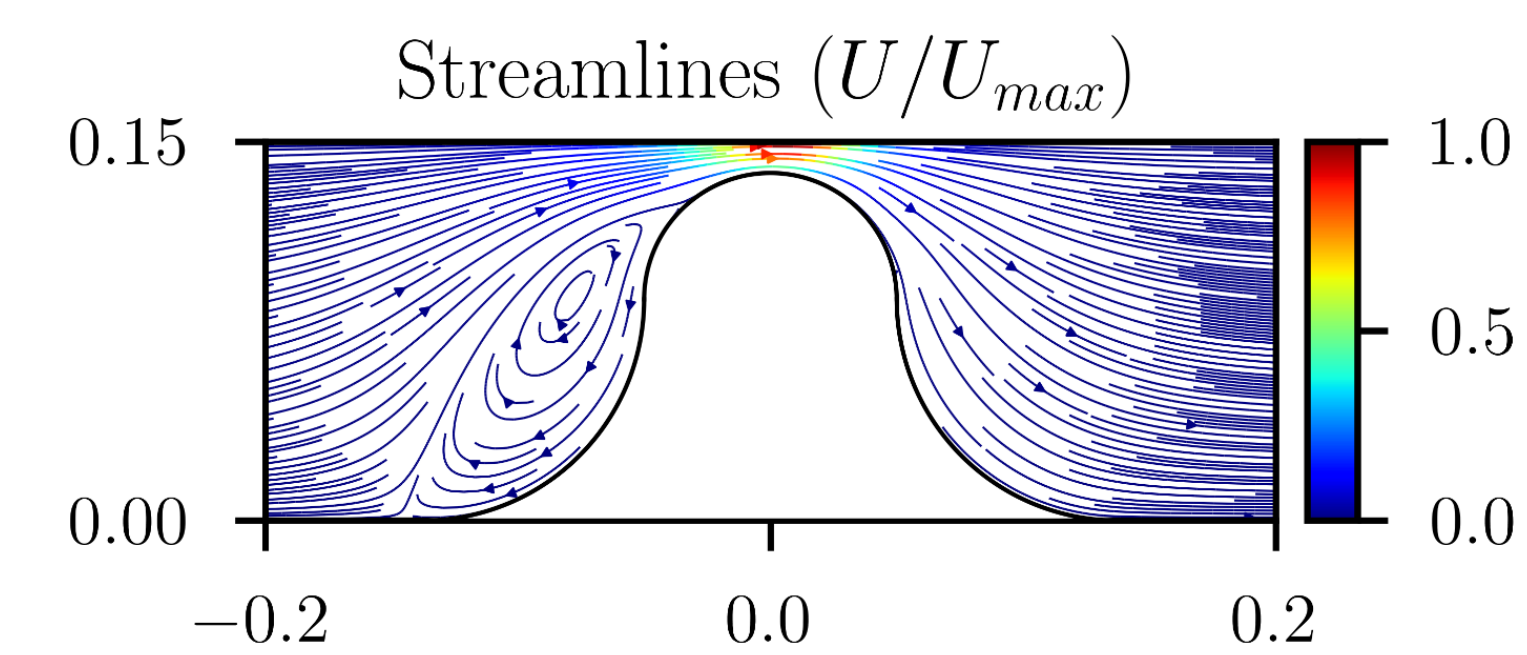
Unpicking the impact of viscoelasticity

Finite volume CFD simulations performed on the UK national supercomputing service (ARCHER2) revealed that when both shear-thinning and elastic characteristics are considered there is upstream recirculation leading to a larger energy loss and a greater fluid-particle interaction force. This conclusion has been further confirmed by the microfluidics experiments.

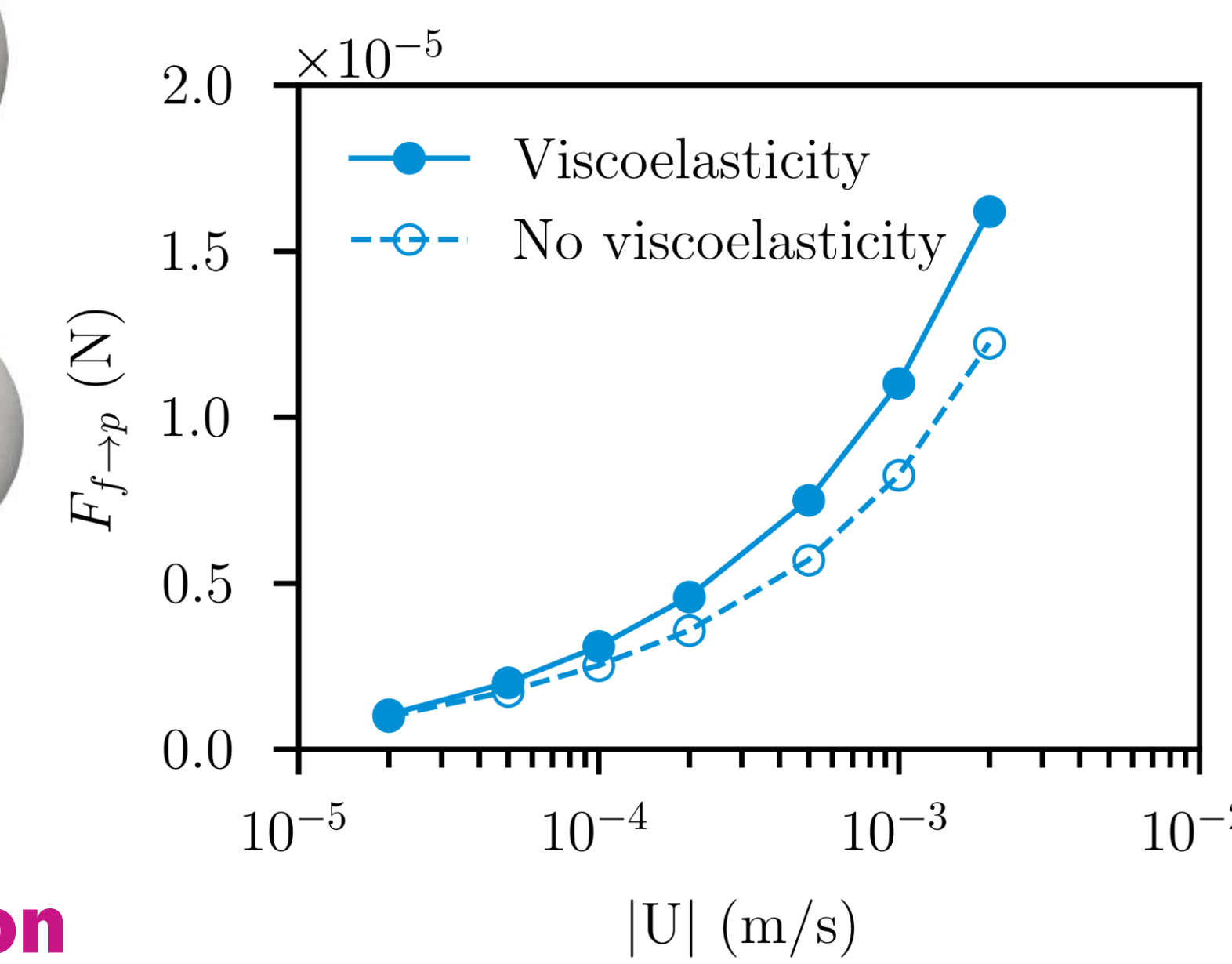
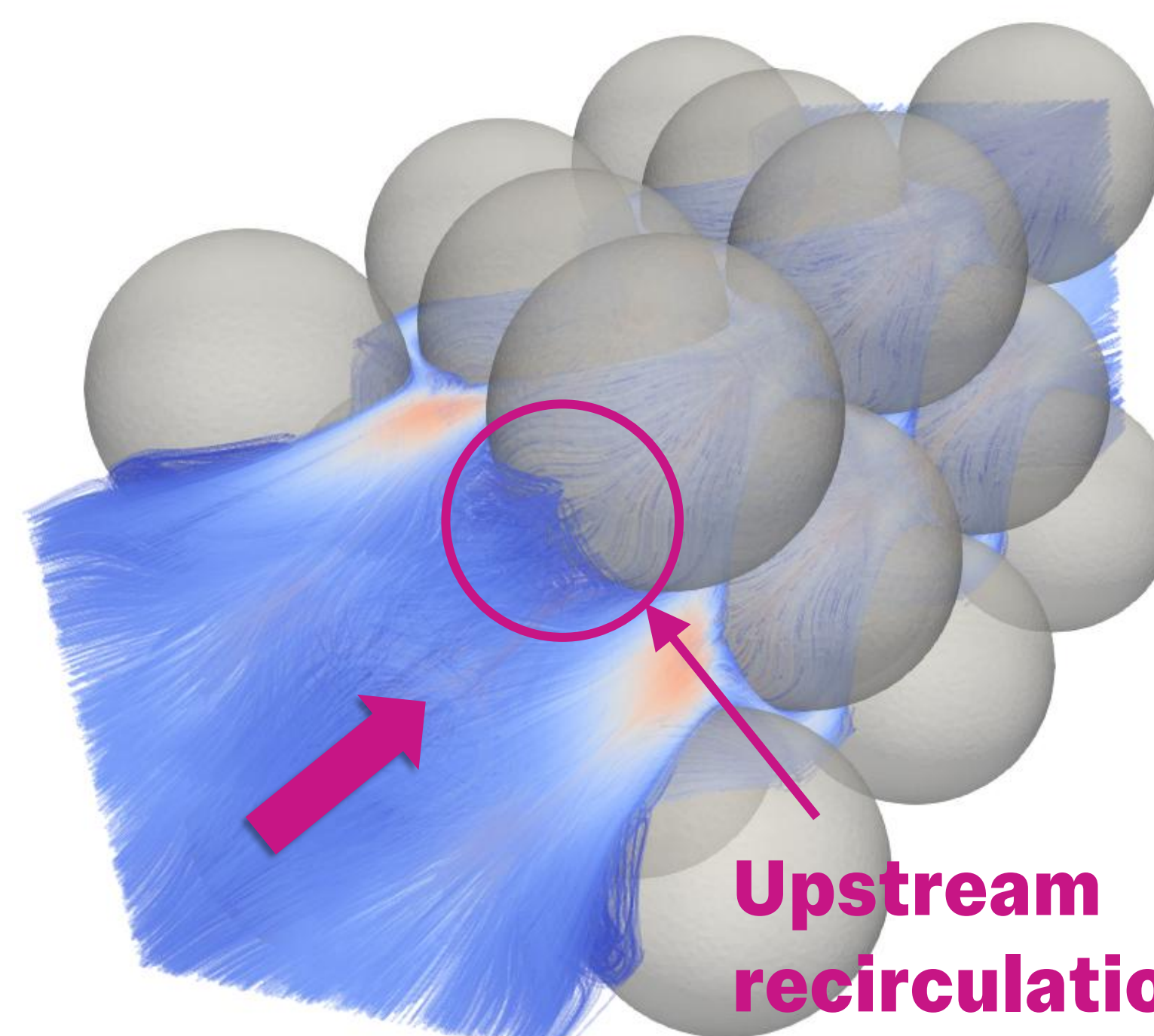
No viscoelasticity (Carreau)



Viscoelastic model (FENE-P)



Flow through packed beads Fluid-particle interaction force



Conclusions

- Viscoelasticity effects may provide extra support force.
- Numerical simulations play an essential role in interpreting tests used in material quality control on construction sites.
- Further research is required to link the in-situ and real-time data with the digital twins.

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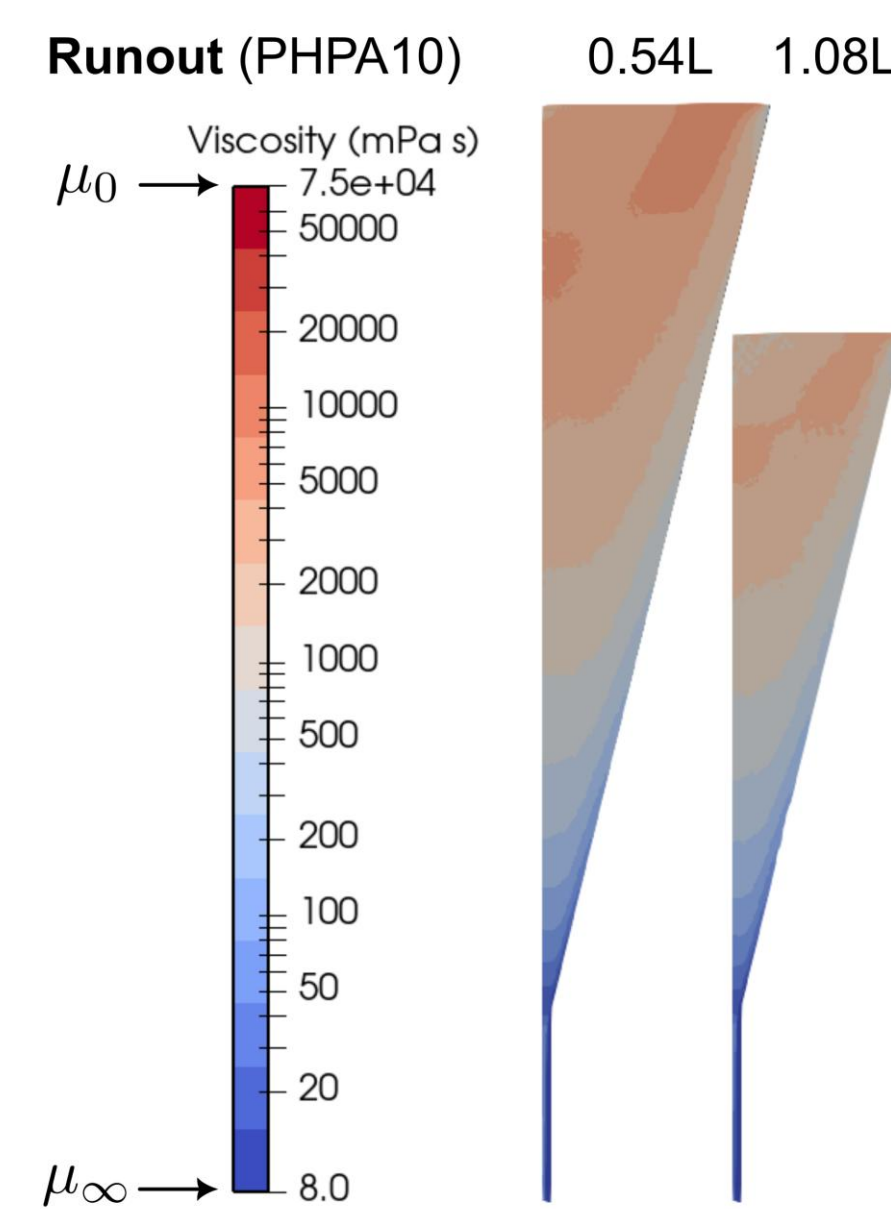


Appraisal of polymer fluid quality control tests

Test fluids

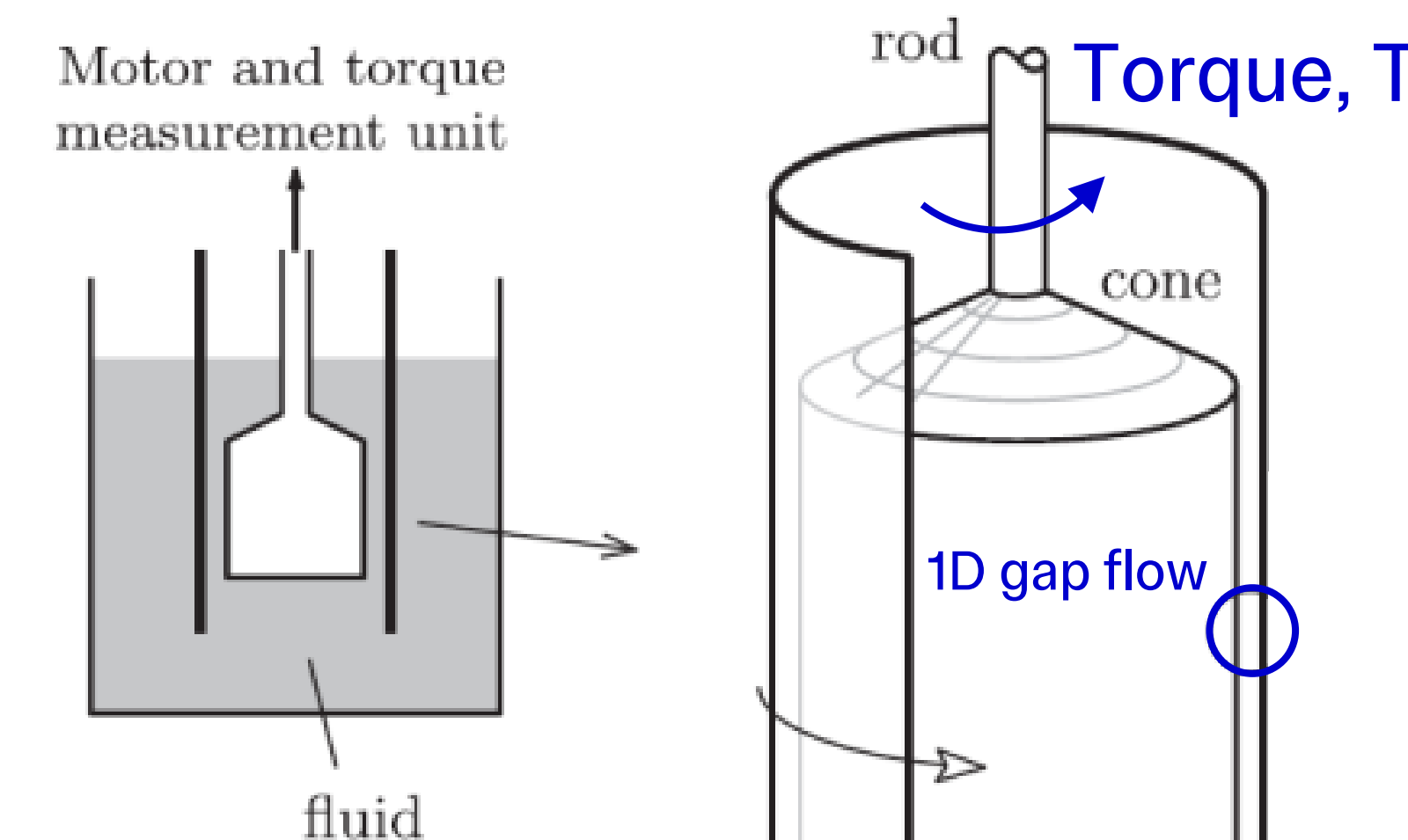


Marsh Funnel



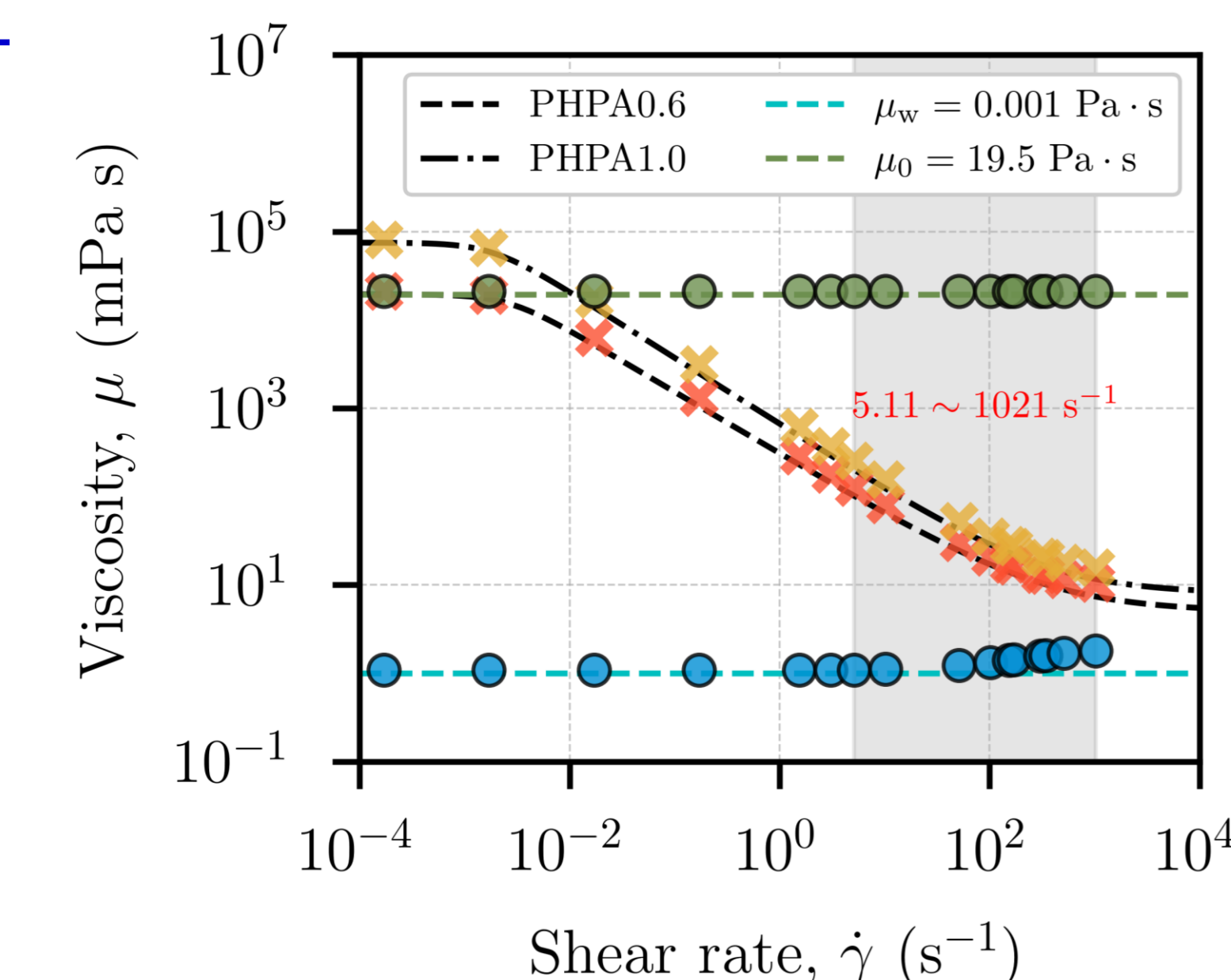
Marsh Funnel

Multiphase Computational Fluid Dynamics (CFD) simulations have revealed that the Marsh funnel which is used on site cannot give accurate apparent viscosity data for typical polymer fluids used in ground engineering at high shear rates.



Fann viscometer

Lac & Parry (2017)



Fann Viscometer

High-resolution CFD simulations of the Fann viscometer has confirmed the ability of this instrument used to measure the apparent viscosity accurately over a range of fixed rotational speeds.