An elastoplastic 1D Winkler model for suction caisson foundations under combined loading

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Ørsted Wind Power

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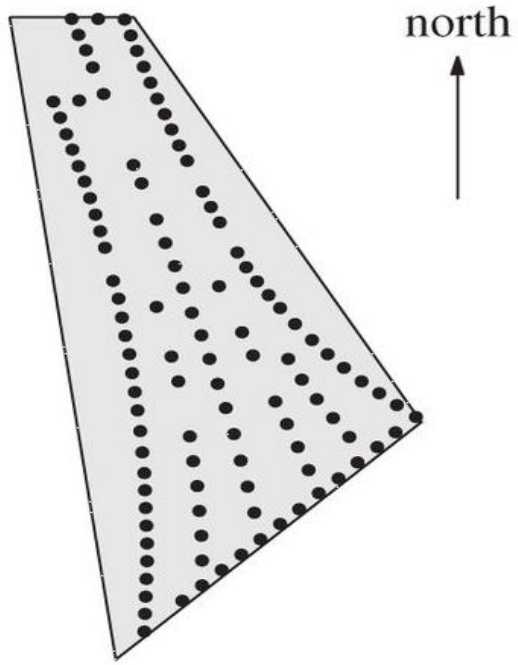
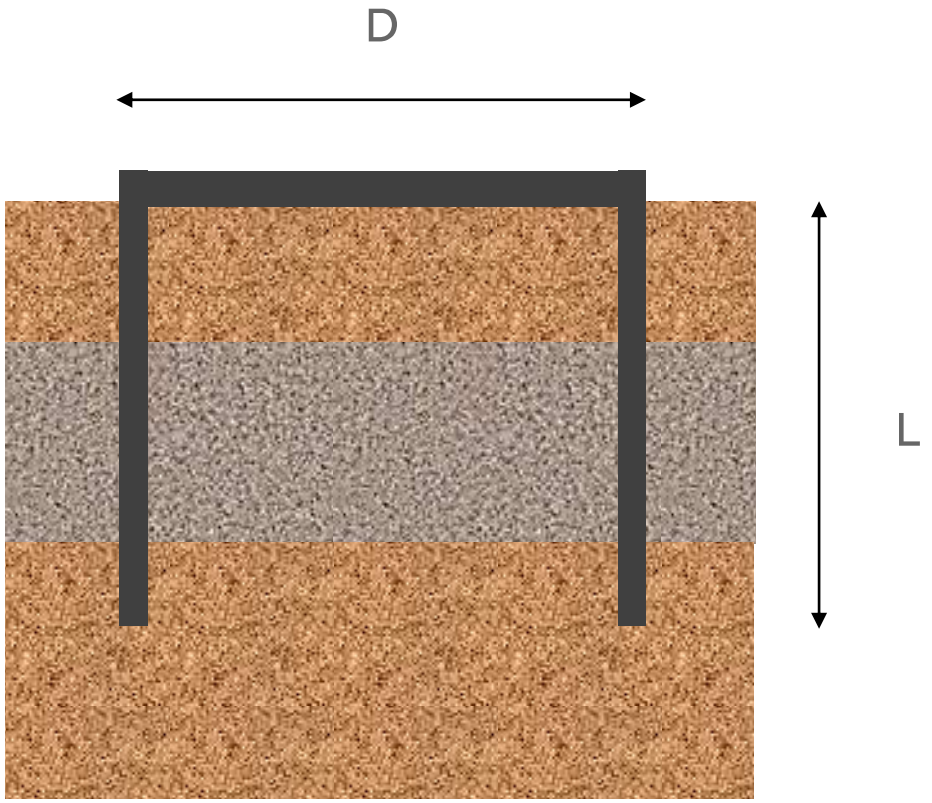
Introduction



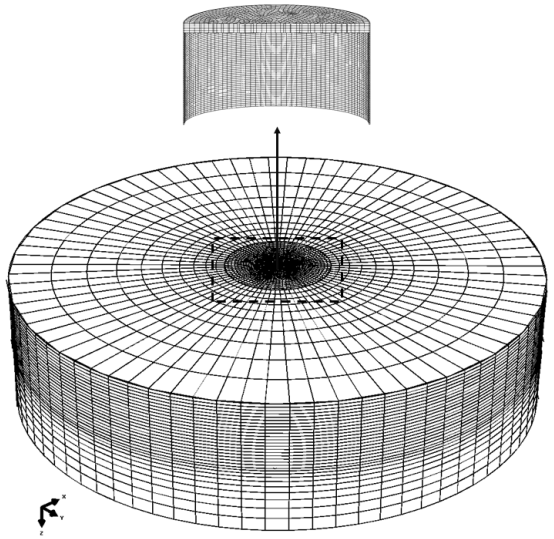
Efficient computations



Getting Larger → Multi-layered

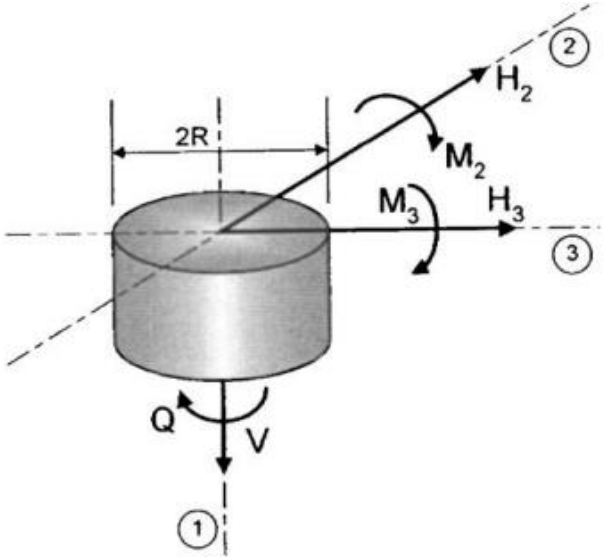
Research Problem

Existing design methods do not meet these requirements



3DFE model

Not efficient



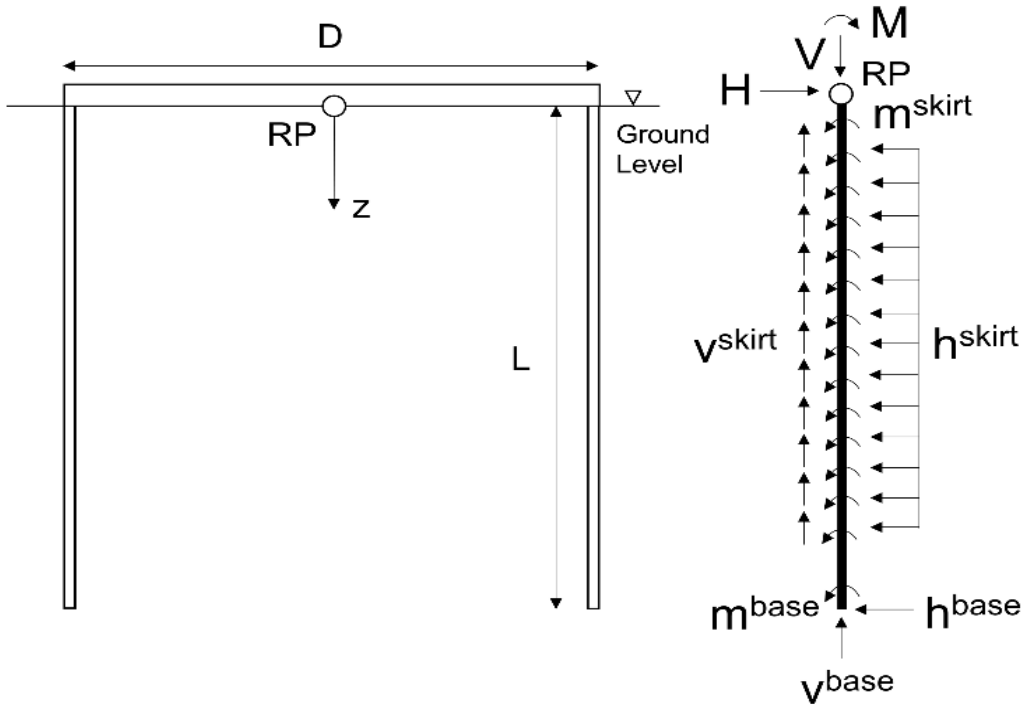
Macro-element model

Does not work well with multi-layered soil profiles

Winkler Model

Suryasentana et al. (2017)
Simplified Model For The Stiffness Of Suction Caisson Foundations Under 6DoF loading

- Skirt soil reactions distributed along skirt
- Base soil reactions concentrated at the base of the skirt



Ⓧ Assumes linear elastic soil

How about soil non-linearity?

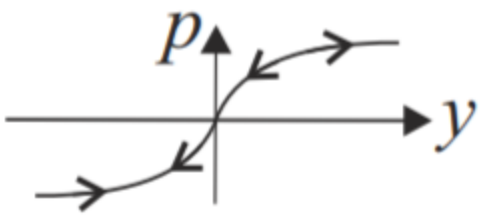
Winkler Model

Pile Winkler Models

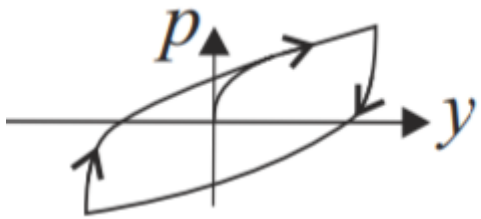
- Non-linear elastic soil reactions

  ⓧ Cannot model hysteresis or permanent displacement

  ⓧ Cannot account for combined loading effects on the failure state



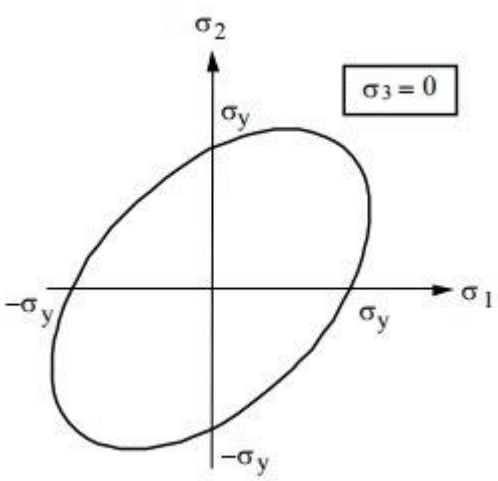
Assumed soil reaction behaviour



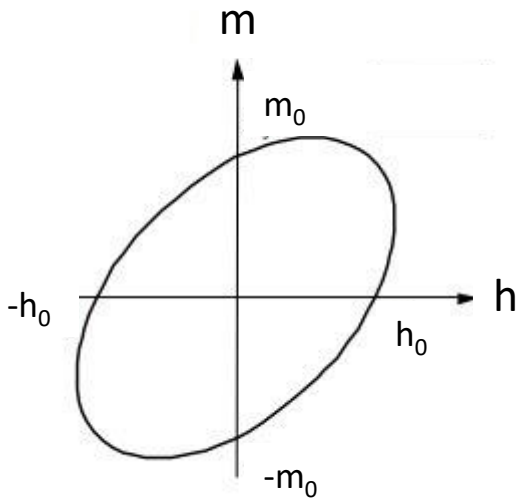
True soil reaction behaviour

Proposed Solution

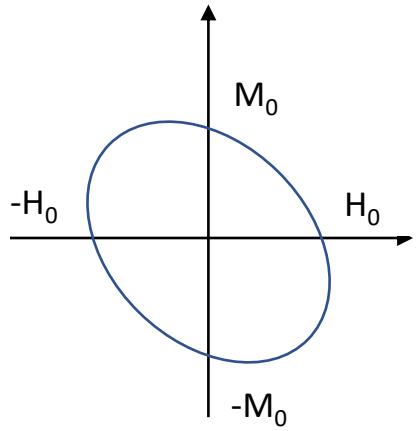
- Couple plastic yield surfaces to Winkler soil reactions



Elemental Yield Surface



Soil Reaction Yield Surface

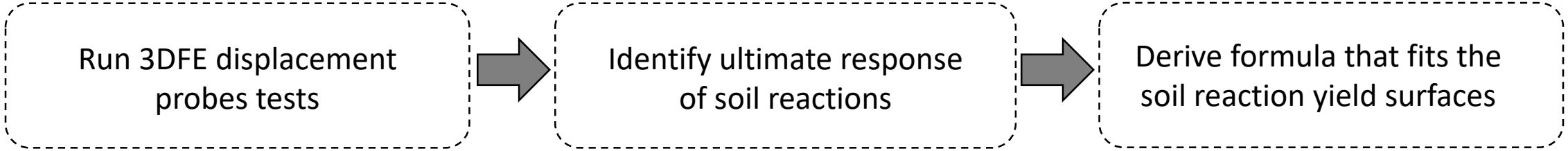


Global Failure Envelope
(Macro-element models)

What are the formulations for the soil reaction yield surfaces?

Calibration Strategy

- Derive local yield surface formulation from 3DFE simulations



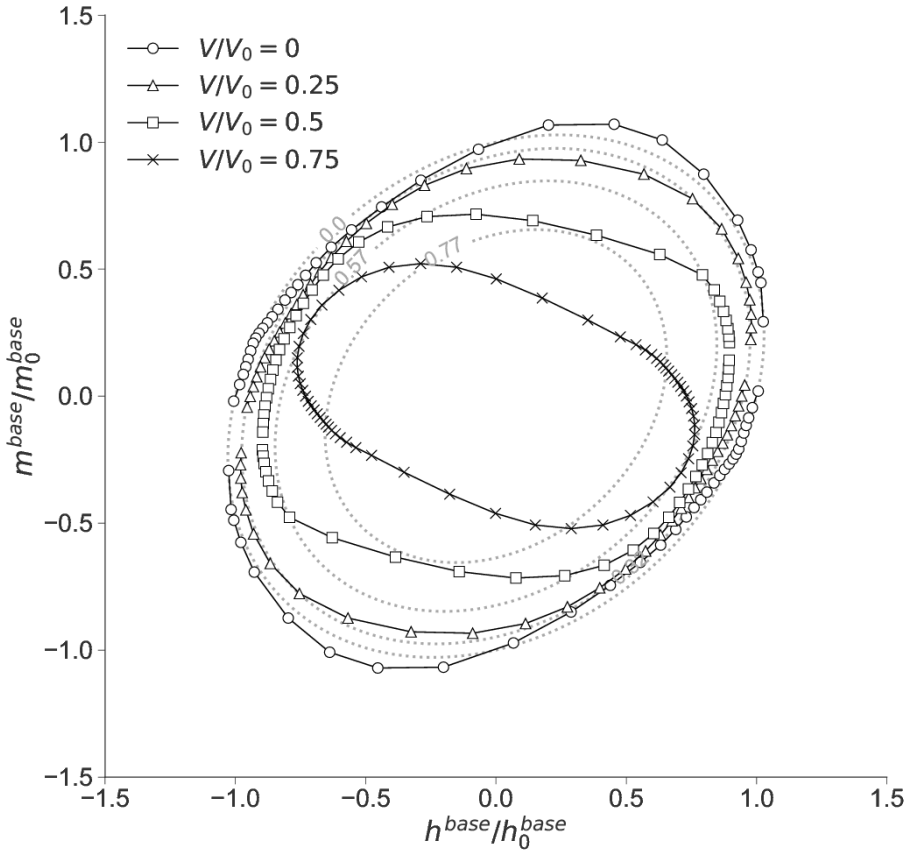
- Case Study:
  L/D = 1
  Von Mises Soil (Undrained Clay)
  Planar VHM loading

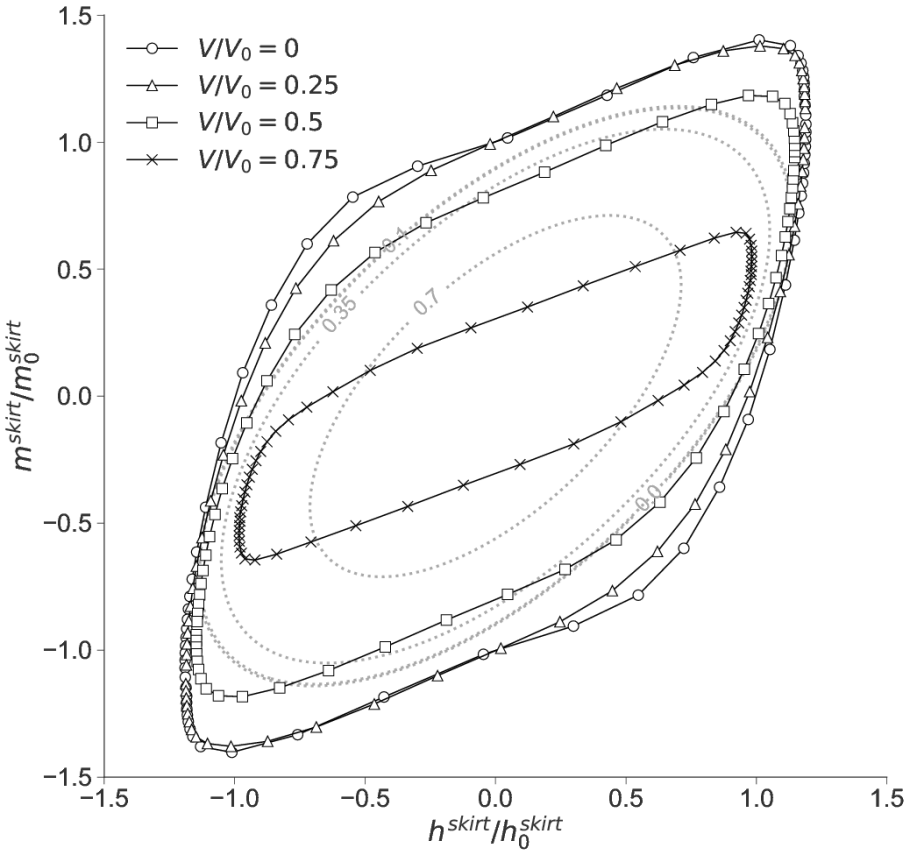
Calibration Results

Parameter	Skirt	Base
v_0/s_u	A^{skirt}	$9.1A^{base}$
h_0/s_u	$2.07A^{skirt}$	$1.34A^{base}$
m_0/s_u	$0.19A^{skirt}D$	$0.72A^{base}D$
α	-1.23	-0.47

$$f = \left(\frac{v}{v_0}\right)^2 + \left(\frac{h}{h_0}\right)^2 + \left(\frac{m}{m_0}\right)^2 + \alpha\left(\frac{hm}{h_0 m_0}\right) - 1$$

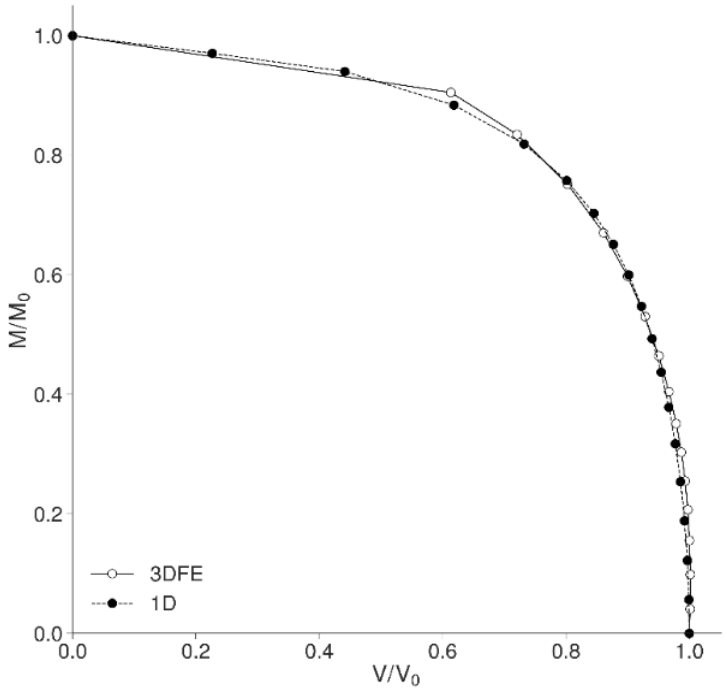
v_0, h_0, m_0 = uniaxial capacities

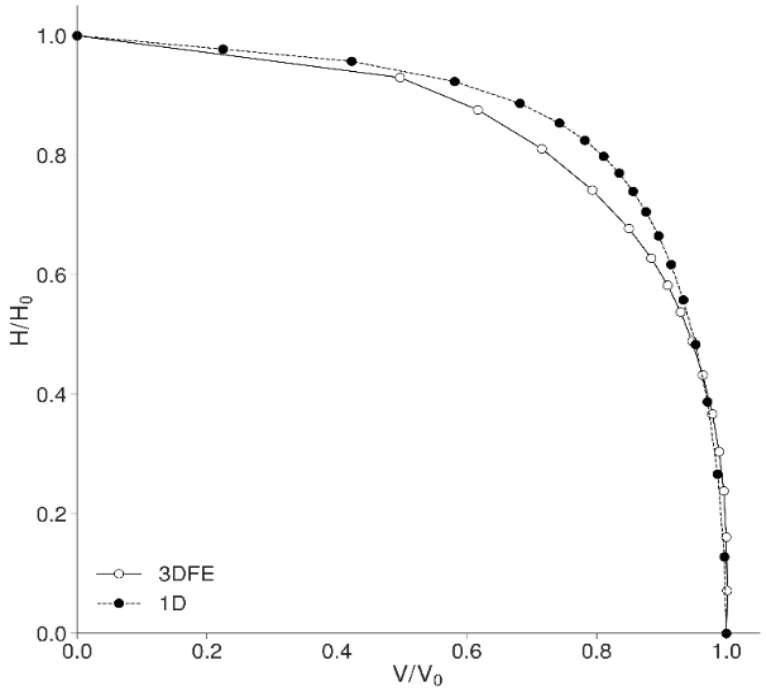


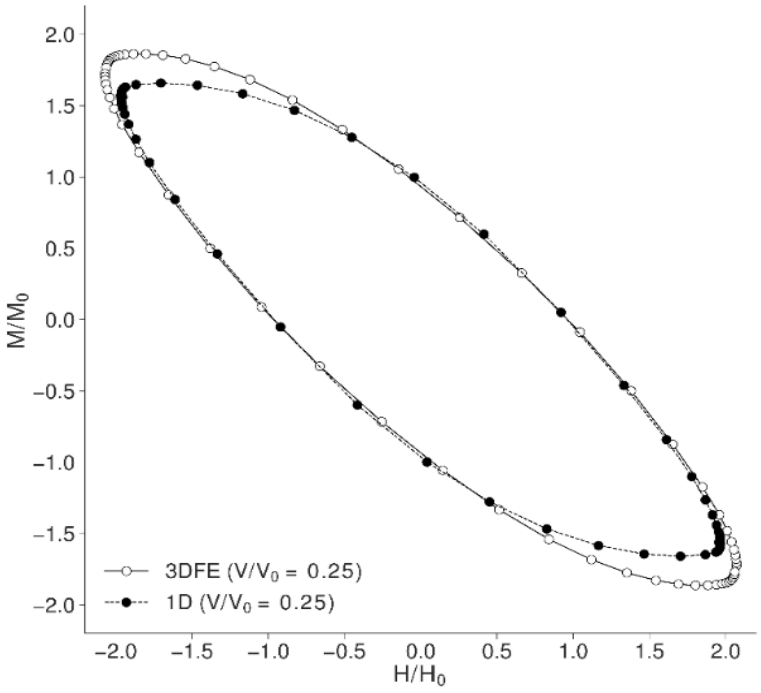


Results

Global failure envelope predictions

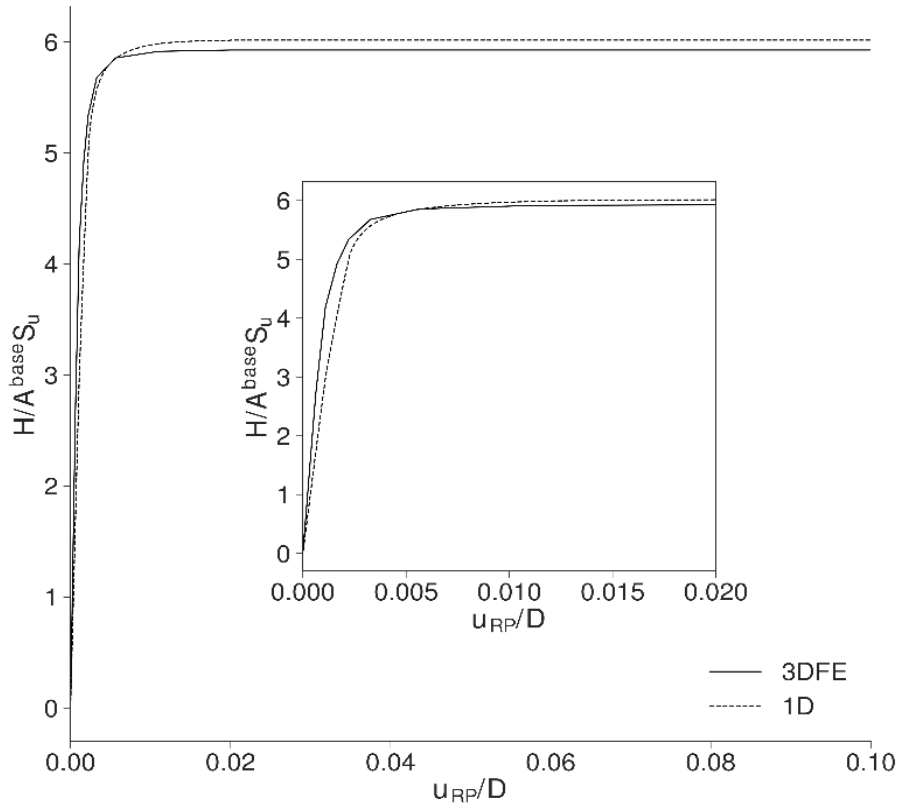




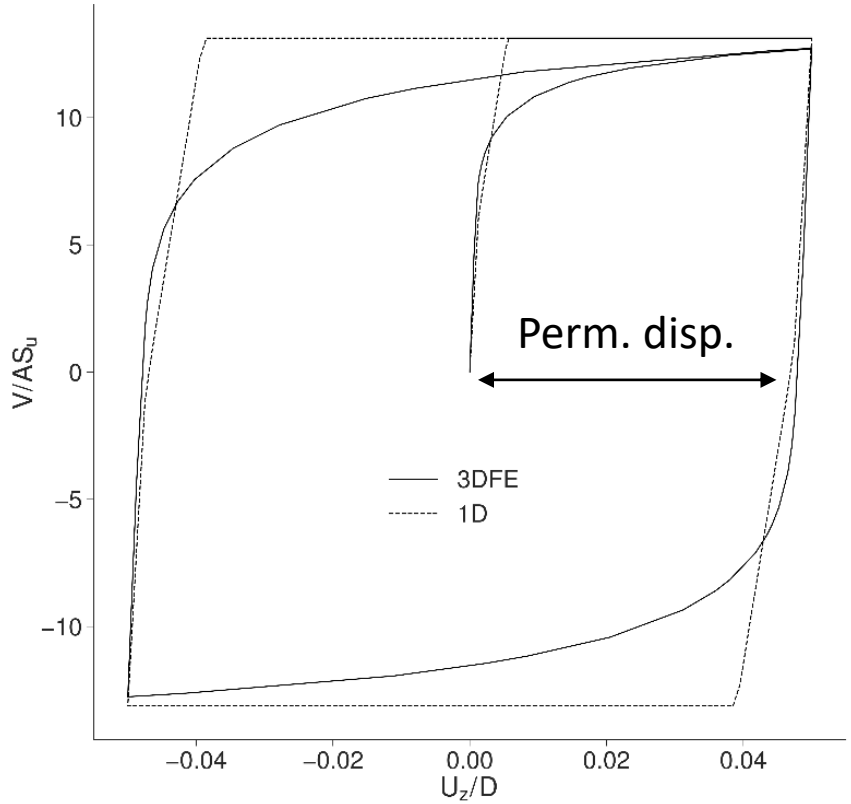


Results

Load-displacement predictions



Monotonic Loading



Cyclic Loading

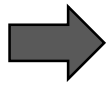
Summary

Elastoplastic Winkler model allows quick (takes 3% of the time) reproduction of the salient features of elastoplastic 3DFE simulations:

- Non-linear load-displacement behaviour
- Hysteresis
- Combined loading effects on the failure state

Limitations

- L/D = 1
- Planar VHM loading



Addressed in an upcoming paper