Geotechnical Engineering Research Group
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UNIVERSITY OF OXFORD

# Finite Element Analysis of Soil Plug Behaviour within Open-Ended Piles

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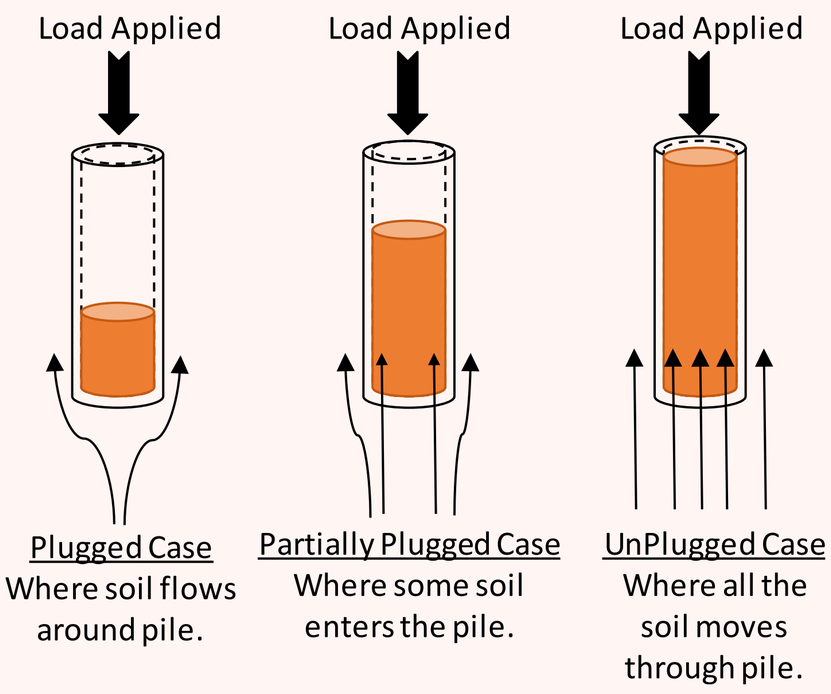
ATKINS EPSRC

## Problem Statement

The main pile design methods for open-ended piles include the API RP2 GEO (2011), the UWA-05 and the ICP-05. Each consider the effects of the soil plug differently and this varies the length and cost of offshore foundations.

***So how can we as an industry improve on this?***

## How is the soil plug currently understood to behave under the actions of axial load?




Plugged Case
Where soil flows around pile.

Partially Plugged Case
Where some soil enters the pile.

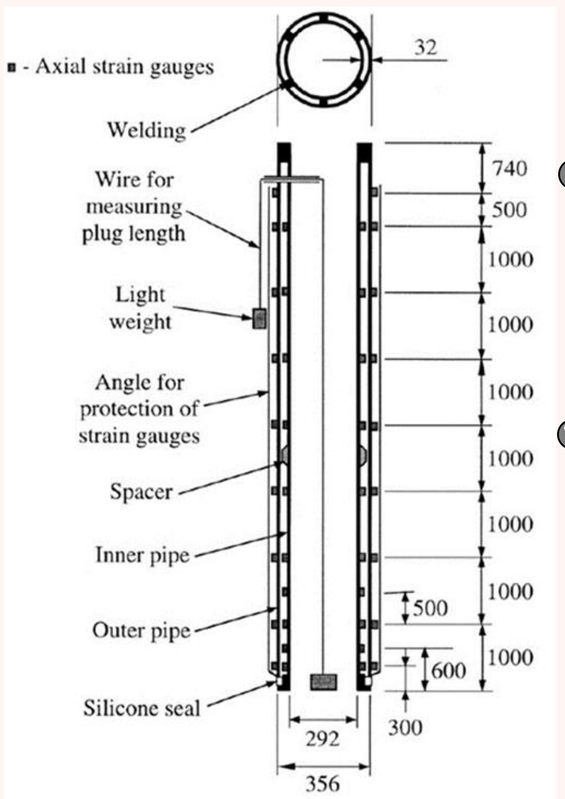
UnPlugged Case
Where all the soil moves through pile.

Which of these cases actually replicate the true behaviour of the soil plug?

To improve our understanding of this issue we turn to experimentation and the use of finite elements.

## Soil Plug Experimentation

This is a unique type of pile test. Instead of only one pile, this test uses a double walled pile. This allows the soil plug to be effectively isolated from the effects of the surrounding soil.

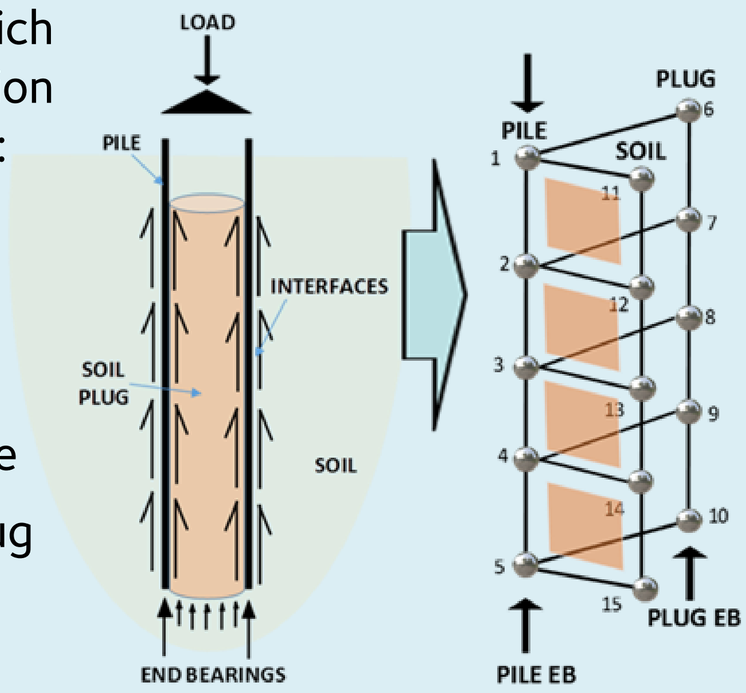



***One of the main findings from these tests is that the plug is mobilised from the base upwards!***

## Finite Element Model of an Open-Ended Pile

A model can be created which links the following foundation components mathematically:

- the pile
- the plug
- the surrounding soil
- the end bearing on the pile
- the end bearing on the plug
- The internal interface
- The external interface



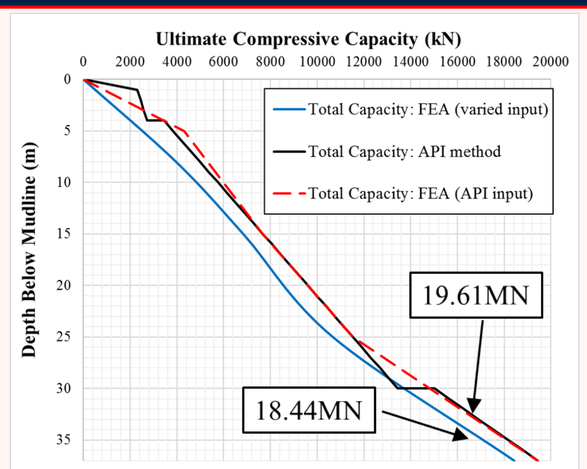

$$\frac{d\sigma_p}{dz}A_p + \frac{d\sigma_{pl}}{dz}A_{pl} + \tau_s P_e + \tau_{i,i} P_i + \tau_{e,i} P_e = 0$$

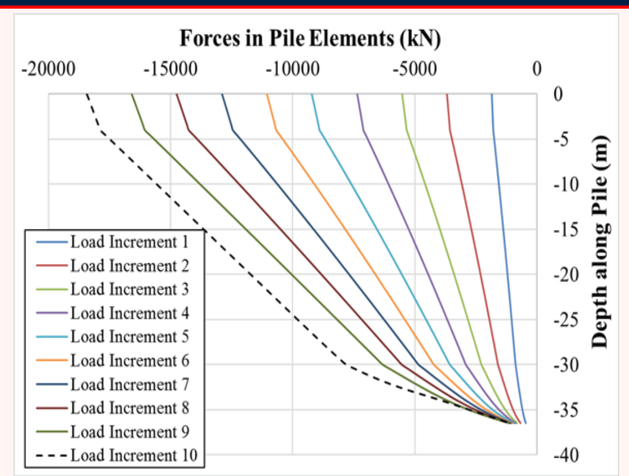
## Application of the Model

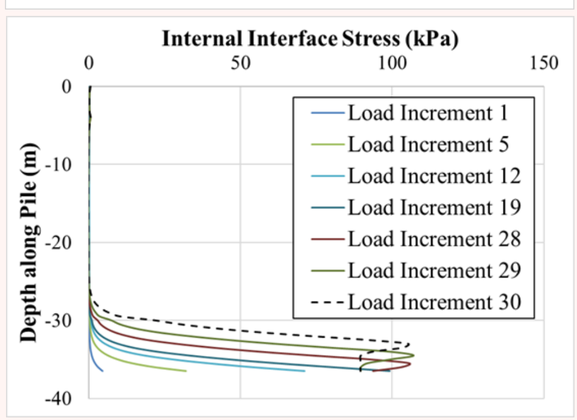
Case study selected: 37m pile offshore
Soil conditions: Cohesive

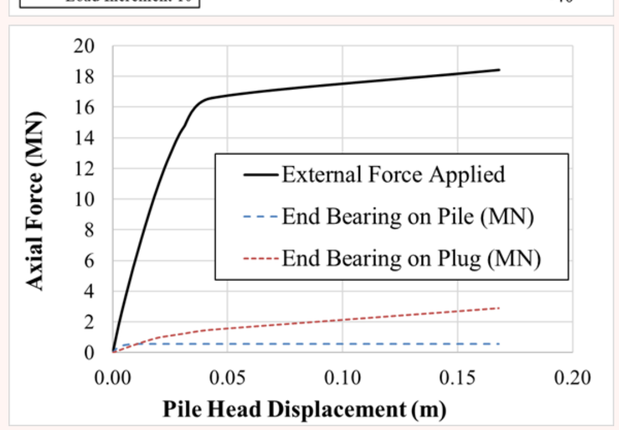
Design method: API RP2 GEO (2011)
Pile stiffness: Rigid
Plug stiffness: Infinite
API capacity estimate: 19.61MN

Design method: API-FEA
Pile stiffness: Compressible
Plug stiffness: Compressible
FE analysis estimate: 18.44MN




## Further work

- Compare results from program with database of case studies in sands and clays
- Update the existing end bearing capacity relationships for open-ended piles.
- Enhance model of plug considering partial drainage

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