



## BACKGROUND

The axial capacity of piled foundations is a function of the proportion of the **undrained shear strength,  $S_u$** , of the soil that is mobilised at the base and shaft of the pile. The mobilisation of the base and shaft resistance occurs through **settlement** of the pile. In practice, the axial capacity (sum of the proportion of base and shaft resistance) of a pile is estimated using empirical bearing coefficients  $N_c$  and  $\alpha$ , and is dependent on the pile's **geometry**.

$$Q_{ult} = A_b S_{u_{base}} N_c + A_s S_{u_{avg}} \alpha$$

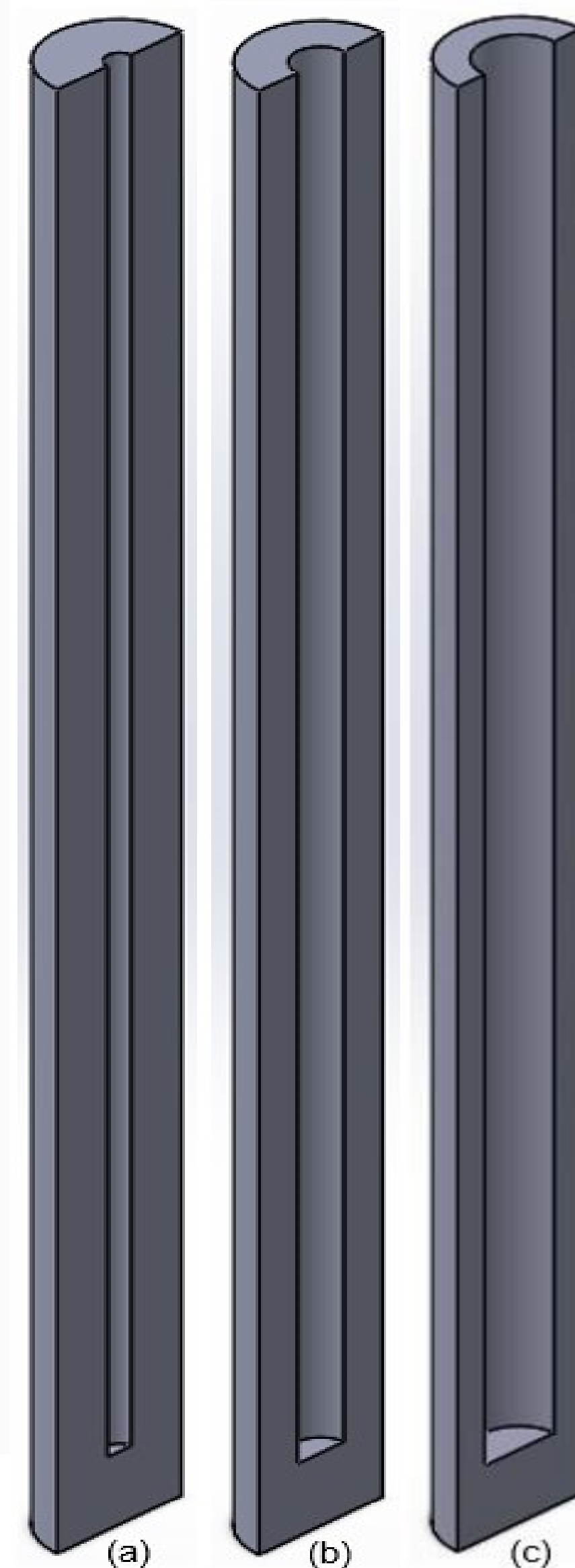
- $Q_{ult}$  - Ultimate bearing capacity
- $A_b$  - Area of pile base
- $S_u$  - Undrained shear strength
- $N_c$  - Coefficient of bearing capacity
- $A_s$  - Shaft surface area
- $\alpha$  - Adhesion factor

This research is aimed at investigating how the behaviour of piled foundations is affected by an inclusion of a **hollow core** at the centre of the pile.

## MODEL PILE DESIGN

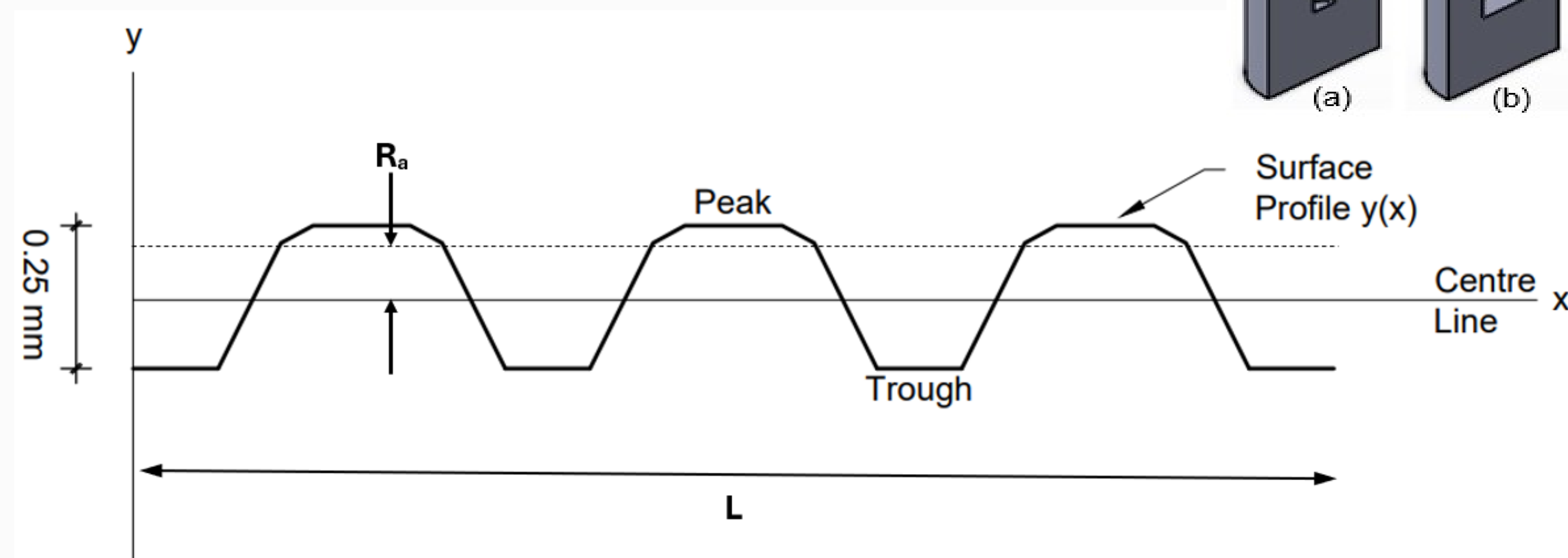
Model pile foundations printed using 3D printing technology in two halves. 3D printing was chosen for the piles within this research to ensure that the **surface roughness** of the piles could be standardised.

Roughness Parameter	Concrete Block	Model Pile
$R_a$ ( $\mu\text{m}$ )	12.06	11.98
R	6.03	5.99



$$R_a = \frac{1}{L} \int_0^L |y(x)| dx; \quad R = \frac{R_a}{D_{50}}$$

- $R_a$  - Centre Line Average
- R - Relative Roughness
- L - Pile Length
- $D_{50}$  - Average Particle Size



Different axial stiffness values for the model piles were achieved by:

- Varying the **diameter** of the hollow core (3, 6, and 9mm)
- Varying the 3D printing **material** for the piles (OnyxOne and Aluminium)

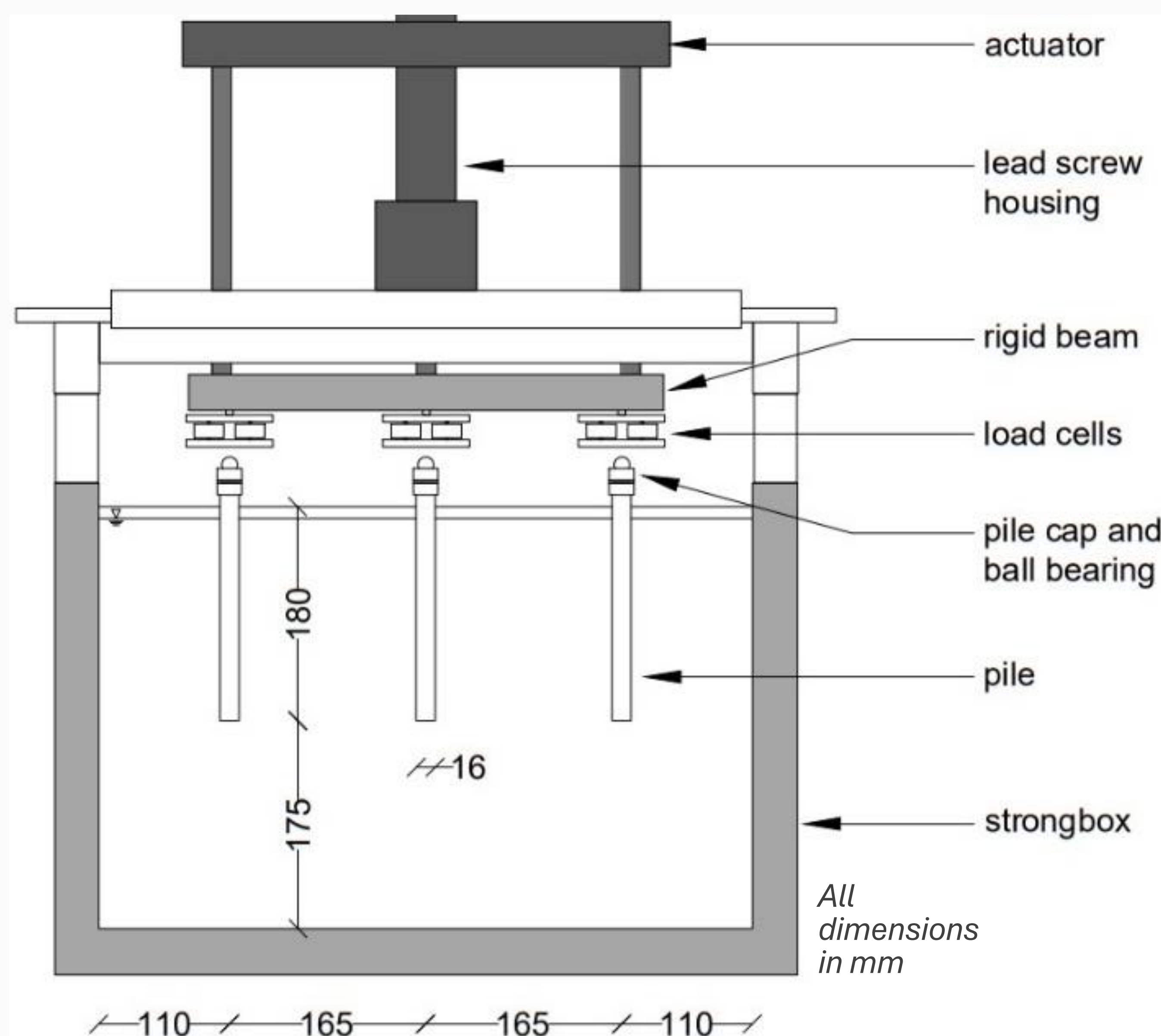


	Pile Material					
	OnyxOne			Aluminium		
Hollow Core Diameter (mm)	9	6	3	9	6	3
Axial Stiffness ( $\times 10^5$ kN/m)	0.93	1.16	1.30	27.2	33.9	37.8

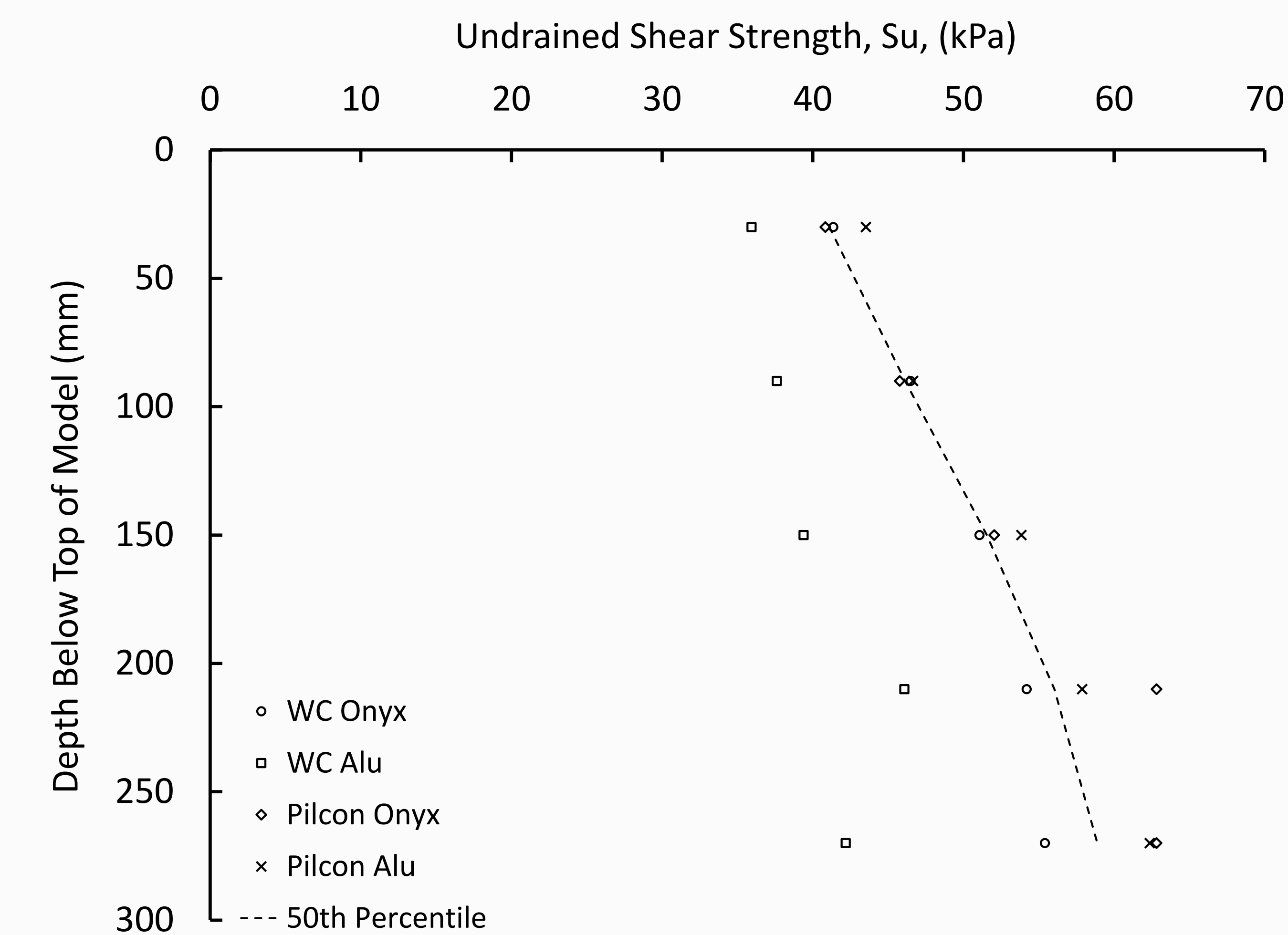
## GEOTECHNICAL CENTRIFUGE TESTS

Model piles were installed in a sample of **Speswhite Kaolin Clay** with an OCR of 2. The model was prepared under 1g conditions and the tests were carried out at **50g**.

Pile embedment depth: **180mm**  
Pile load rate (CRP): **1mm/min**  
Pile diameter: **16mm**  
Water table: **10mm BGL**

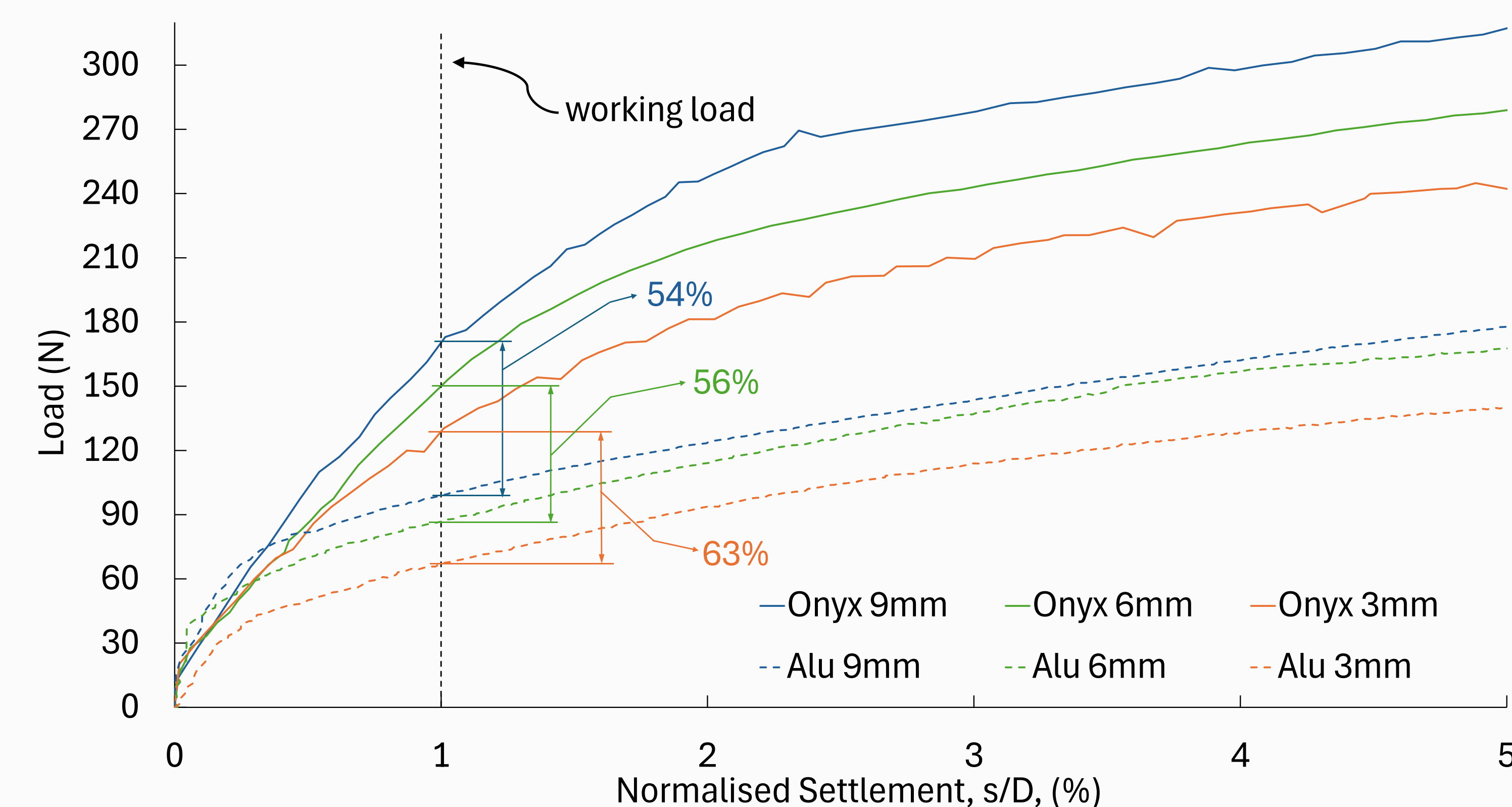


The undrained shear strength was measured post-test using a hand shear vane and water content samples.



## RESULTS

The applied load is plotted against the normalised pile settlement in each test:



There is a considerable difference between pile capacity at **working load** (taken as 1% normalised displacement) between the six tested piles. This relationship could be seen as an increase in pile capacity resulting from a reduction in pile stiffness.

Comparing the OnyxOne and Aluminium piles with identical hollow cores, the percentage increase in pile capacity at 1% is noted on the graph.

The results support the theory that reducing the axial stiffness of a pile increases the proportion of undrained shear strength which is mobilised along the pile length, likely due to an increase in strain.