Mechanical properties of concrete pile-sand interface with a filter cake
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INTRODUCTION
When concrete is cast in the ground, a filter cake (also called mud cake) is often formed between concrete and soil. This filter cake can serve as a barrier and minimize fluid loss, thus stabilizing the excavation of holes or trenches.

However, the filter cake may create an undesirable concrete–soil interface; this can reduce the interface shear resistance. Therefore, it is important to investigate the effect of the filter cake on the mechanical properties of the concrete pile-sand interface.

PILE SURFACE ROUGHNESS

Characterizing Bored Pile Diameter Variation
Bored pile diameter profiles were determined from eight bored piles using aperture detection systems. These profiles were used to analyze the changes of pile diameter and surface roughness.

• The pile radial increase generally ranged from 0 to 50 mm with a frequency of 96.6%.
• The increase in the average radial bulge size was approximately 27.6 mm.

Estimating Pile Surface Roughness:
Geometric relationships:

\[ A = 2\pi r L \]
\[ V = \pi h \]
\[ A = \frac{V}{2\pi r} \]
\[ I = \frac{V}{A} \]

Pile surface roughness \( I \) can be expressed: \( I = r_m - r_a - \frac{\Delta r}{n} \)

• The roughness distribution ranged from 0 to 50 mm with its frequency of 94.0%.
• Take the pile surface roughness values of 10, 20, and 30 mm for investigation.

Concrete blocks with smooth and rough surfaces are used to simulate concrete precast and bored piles, respectively.

\[ L_e = 9h \quad V_e = 4.5h \]

Roughness: \( I = \frac{1}{2} h \)

EXPERIMENTAL TESTS

Large-Scale Direct Shear Test Apparatus
• Dimensions of upper shear box: 500 × 500 × 150 mm.
• Dimensions of lower shear box replaced by concrete blocks: 570 × 570 × 100 mm.

Soil Material and Test Parameters
• Sand: Xiang River sand.
• Filter cake: bentonite or polymer support fluid.

TEST RESULTS

Shear Stress vs. Horizontal Displacement

(a) \( \sigma = 350 \text{ kPa} \)
(b) \( \sigma = 350 \text{ kPa} \)
(c) \( \sigma = 350 \text{ kPa} \)
(d) \( \sigma = 350 \text{ kPa} \)

Peak Shear Strength vs. Filter Cake Thickness

(a) \( \sigma = 350 \text{ kPa} \)
(b) \( \sigma = 350 \text{ kPa} \)
(c) \( \sigma = 350 \text{ kPa} \)
(d) \( \sigma = 350 \text{ kPa} \)

Peak Shear Strength vs. Interface Roughness

(a) \( I = 10 \text{ mm} \)
(b) \( I = 5 \text{ mm} \)
(c) \( I = 10 \text{ mm} \)
(d) \( I = 5 \text{ mm} \)

CONCLUSIONS
1. A method for characterizing pile surface roughness was deduced to the modified way for regular pile surface roughness.
2. For a rough interface, the shear-displacement curves showed a “softening” response. But, for a rough interface with a filter cake of 5 and 10 mm thick, that curves showed a “hardening” response.
3. A major implication of the test results is that, when bentonite is used, the degree of strength reduction depends on both: a.) the thickness of the filter cake, and b.) the roughness of soil-concrete interface.
4. A critical roughness \( I_c \), of 10 mm was found in the test without a filter cake.