

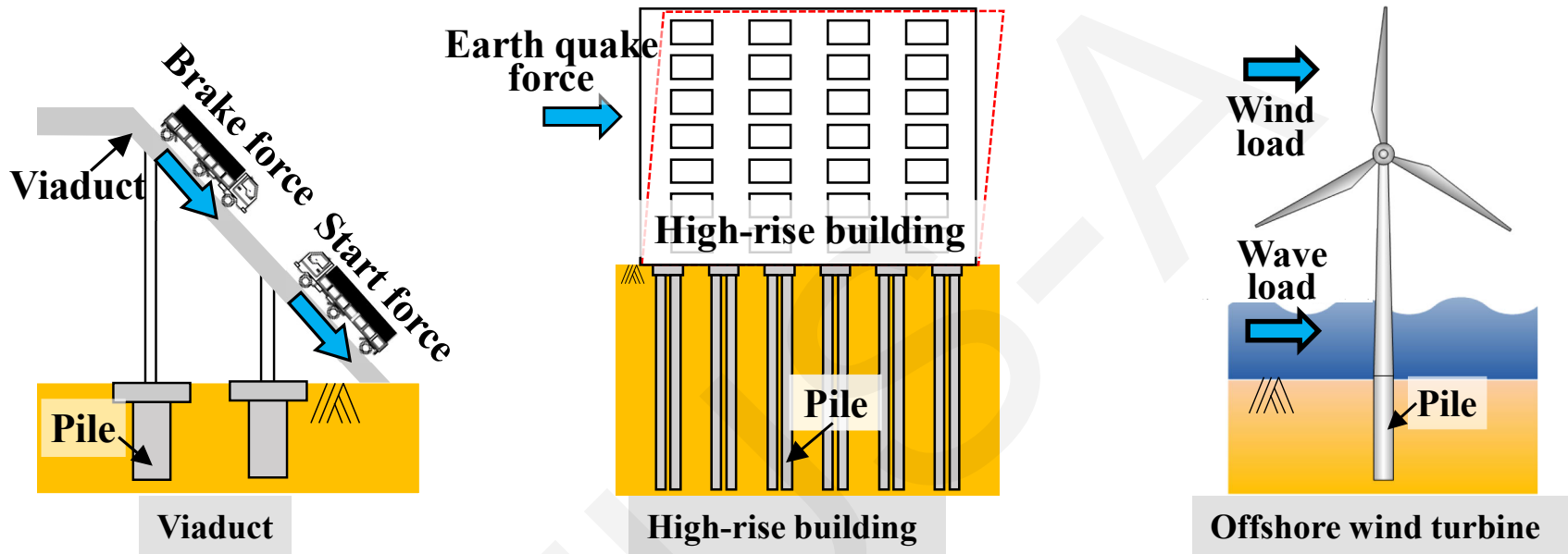
Centrifuge model testing to ascertain vertical displacements of a pile under cyclic lateral loads

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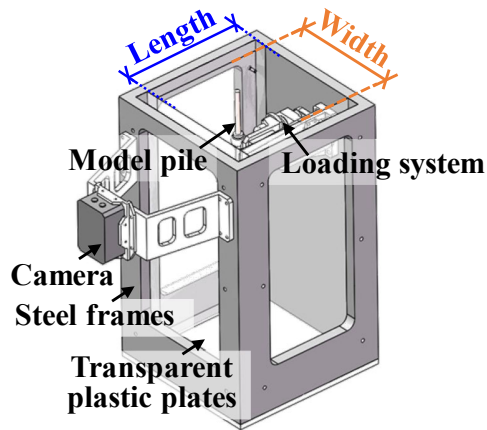
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Introduction

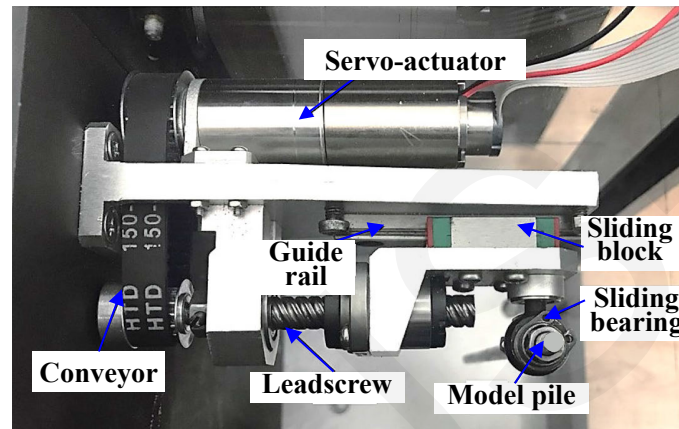


- Piles are inevitably subjected to cyclic lateral loads
- Scant attention has been given to their vertical displacements

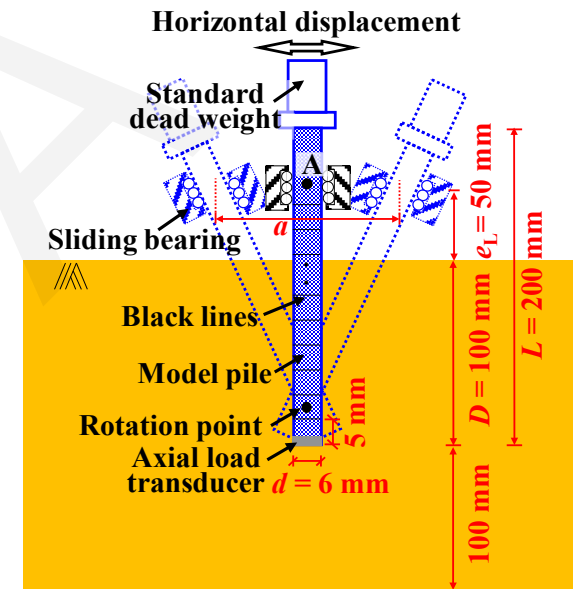
Centrifuge model tests



Strong box



Loading system



Loading process

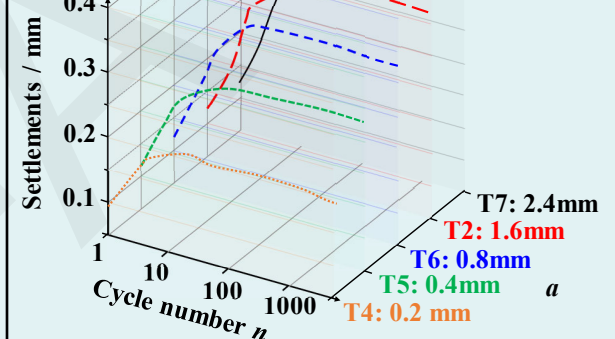
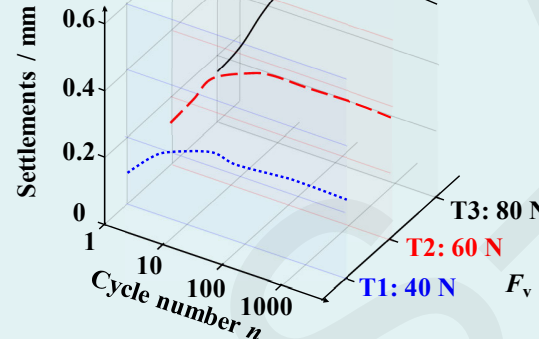
- Tests were conducted in a strong box at 100 g condition
- A self-designed loading system was used to apply a two-way cyclic lateral load to the model pile
- The vertical displacement of the pile was not constrained

Test results

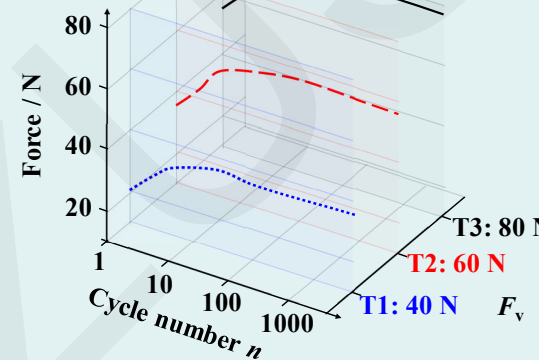
Test information

Test name	Vertical load (F_v , N)	Displacement amplitude (a , mm)
T1	40	1.6
T2	60	1.6
T3	80	1.6
T4	60	0.2
T5	60	0.4
T6	60	0.8
T7	60	2.4

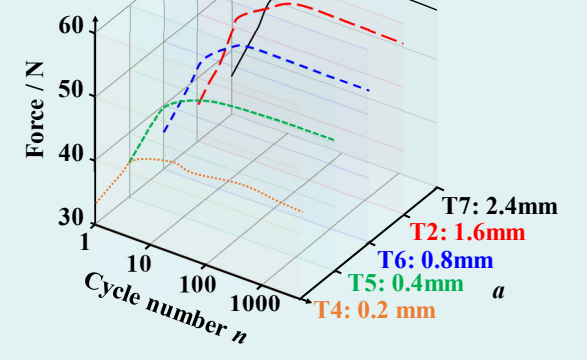
Settlements



Tip resistance



T1 ~ T3

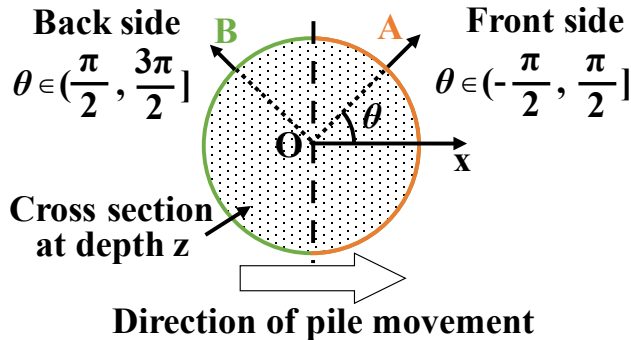


T2 and T4 ~ T7

- 7 tests in total were conducted.
- When F_v and a was larger, the settlement of the pile was more significant.

- In test T1 ~ T3, when F_v was larger, the initial and ultimate tip resistance of the pile was larger.
- When F_v were same in test T2 and T4 ~ T7, the initial tip resistance were same, but the ultimate loads were larger for the pile with larger a .

Pile-settlement mechanism



For ease of clarification

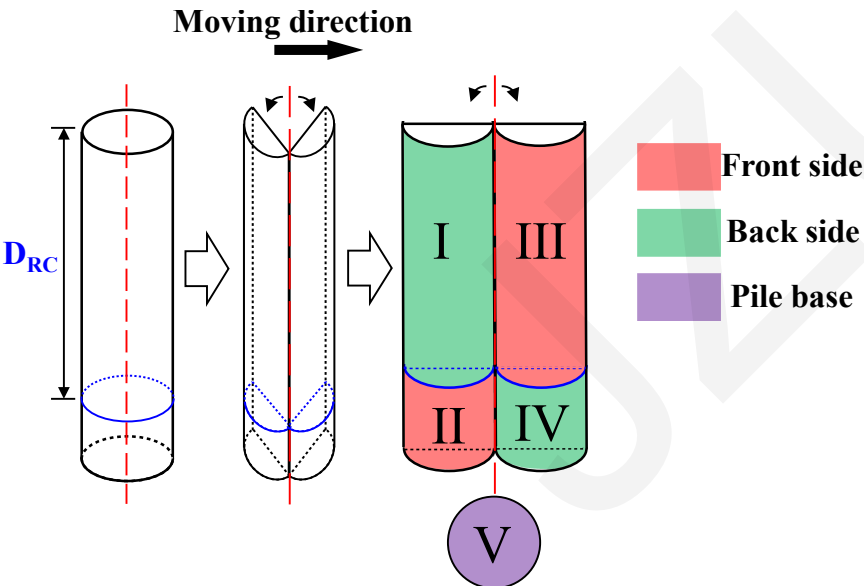
- The half of a given pile section, which had the soil compacted, was termed the “**front side**”
- The other half was termed the “**back side**”

On the front side, the angle θ between Ox and OA

$$\theta \in (-\frac{\pi}{2}, \frac{\pi}{2}]$$

On the back side, the angle θ between Ox and OB

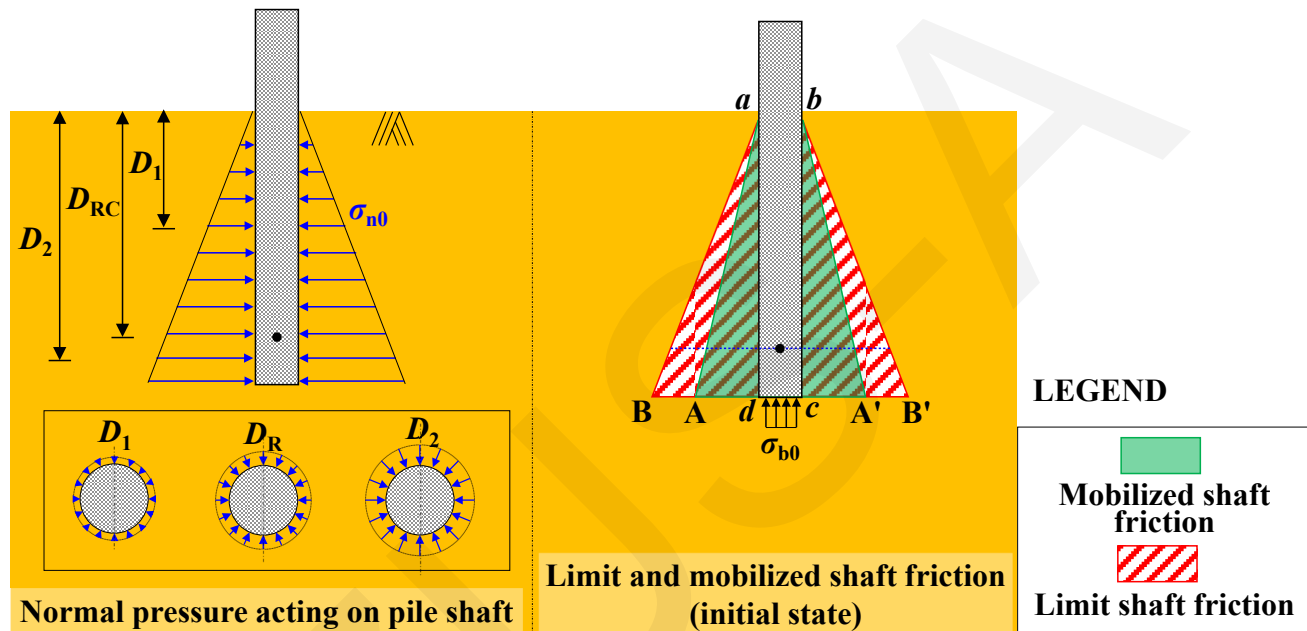
$$\theta \in (\frac{\pi}{2}, \frac{3\pi}{2}]$$



The pile could be divided into five zones belonging to the 3 categories

- Zone I and IV \longrightarrow Back side
- Zone II and III \longrightarrow Front side
- Zone V \longrightarrow Pile base

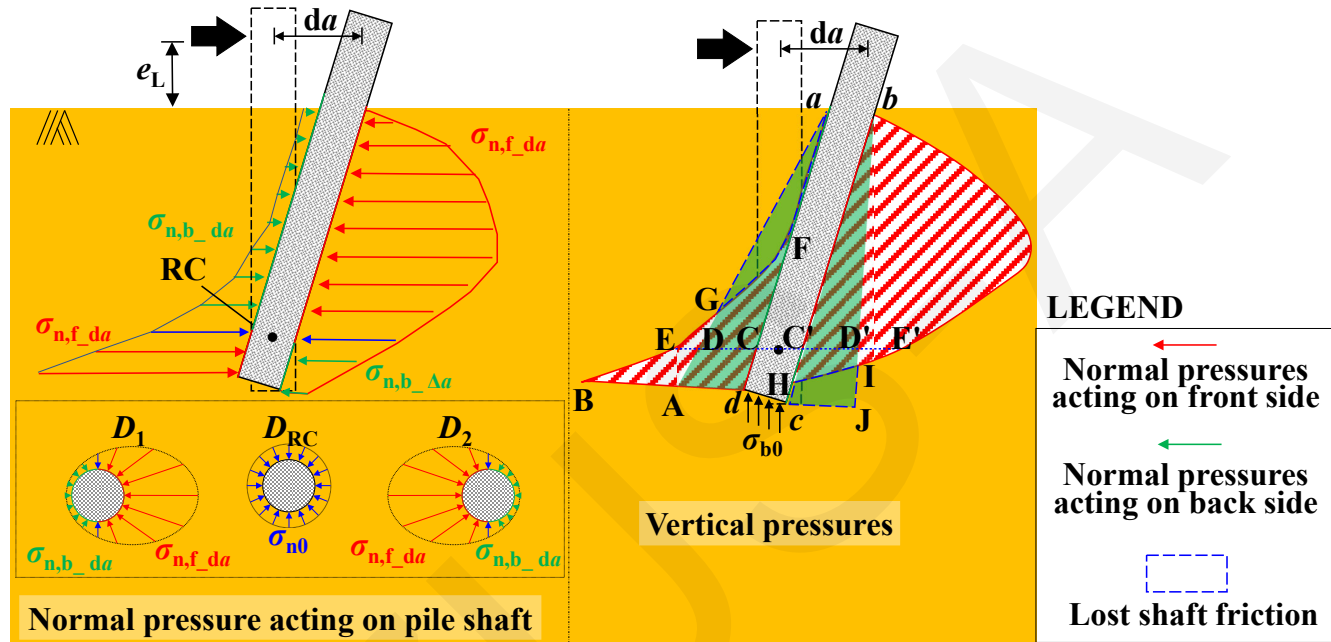
Pile-settlement mechanism



A vertical slice ($abcd$) of the pile was taken to show the mobilized shaft friction

- In the initial state, the normal pressure acting on the pile shaft and the tip resistance are defined as σ_{n0} and σ_{b0} , respectively
- The mobilized shaft frictions on the two sides of vertical cross-section $abcd$ are schematically shown as zones adA and bcA' ; those of the limit states as adB and bcB' , respectively,

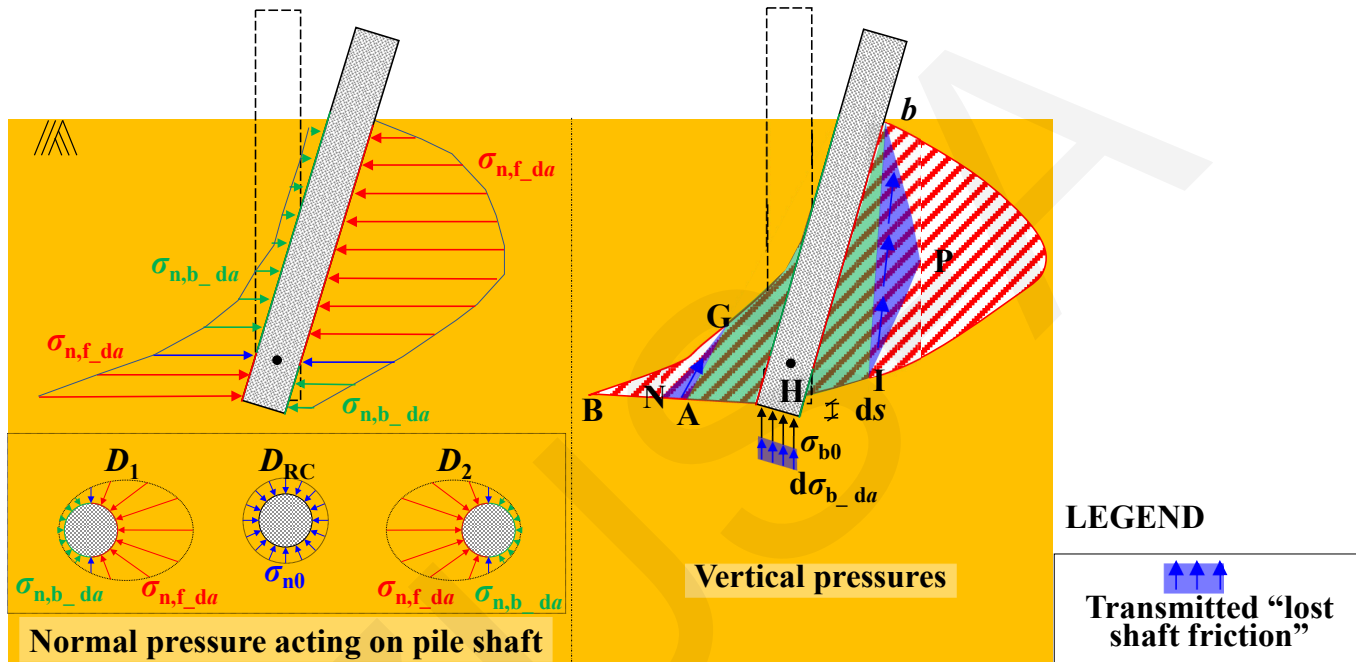
Pile-settlement mechanism



The pile head moves rightwards by da

- The normal pressure on the front side is denoted as σ_{n,f_da} with its limit state distribution schematically shown as $bC'D'E'$ above rotation centre RC and $dCEB$ below RC.
- The normal pressure on the back side is defined as σ_{n,b_da} with its limit state distribution schematically shown as $CFGED$ above rotation centre RC and $C'D'E'IH$ below RC
- When the mobilized shaft friction was larger than the limit shaft friction, a loss in the mobilized shaft friction may be expected on the back side

Pile-settlement mechanism



- The lost shaft friction is transmitted to the pile base such as $d\sigma_{b_da}$ and to the pile shaft such as AGN and bIP
- Due to $d\sigma_{b_da}$, the pile may settle by ds in this da -movement

Conclusions

1. Under a cyclic lateral load, the pile may settle due to the loss of shaft friction
2. The ultimate settlement of the pile is larger when the vertical load or the amplitude of the horizontal displacement is greater.
3. It was deduced that the end-bearing piles would have advantages over friction piles under lateral cyclic loads, considering the effect of the potential loss of the shaft friction of the pile.