Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

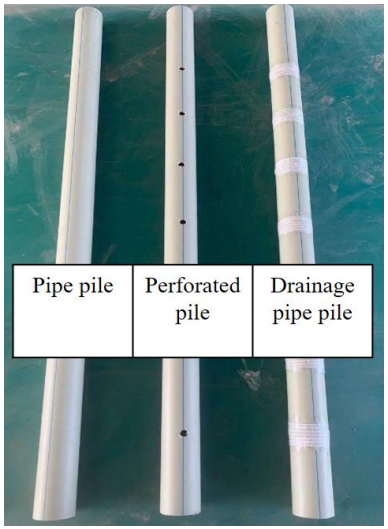
Experimental study of the bearing capacity of a drainage pipe pile under vacuum consolidation

Xiao-wu TANG, Wei-kang LIN, Yuan ZOU, Jia-xin LIANG, Wen-fang ZHAO

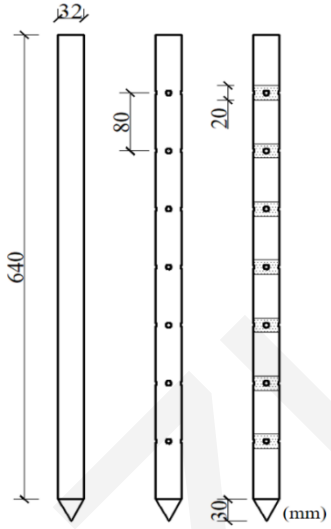
Cite this as: Xiao-wu TANG, Wei-kang LIN, Yuan ZOU, Jia-xin LIANG, Wen-fang ZHAO, 2022. Experimental study of the bearing capacity of a drainage pipe pile under vacuum consolidation. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 23(8):639-651. https://doi.org/10.1631/jzus.A2100585

Test preparation

Three different types of pile models were used in the experiment: a pipe pile, a perforated pile and a drainage pipe pile.



(a)



(b)

Fig. 1 (a) Three different types of pile models
(b) Size of pile models

Table 1 The physical parameters of geotextile

Equivalent aperture o95 (μm)	Permeability coefficient ($cm \cdot s^{-1}$)	Tensile strength ($N \cdot cm^{-1}$)	Longitudinal tear strength (N)	Transverse tear strength (N)
80	5×10^{-3}	36.5	40	40

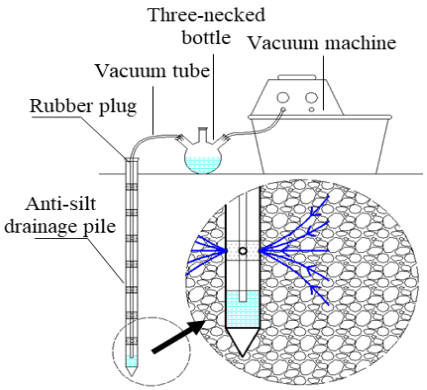


Fig. 2 (a) Vacuum system
(b) Connection mode of vacuum system

Table 2 Physical properties of the clay

Clay	Water content (%)	Unit weight (kN/m^3)	Specific gravity G_s	Void ratio e	Saturation S_r (%)	Plastic limit (%)	Liquid limit (%)
Undisturbed soil	56.35	16.30	2.69	1.58	95.3	27.3	54.5
Remolded soil	80.56	15.20	2.69	2.18	99.4	27.3	54.5

Test methods

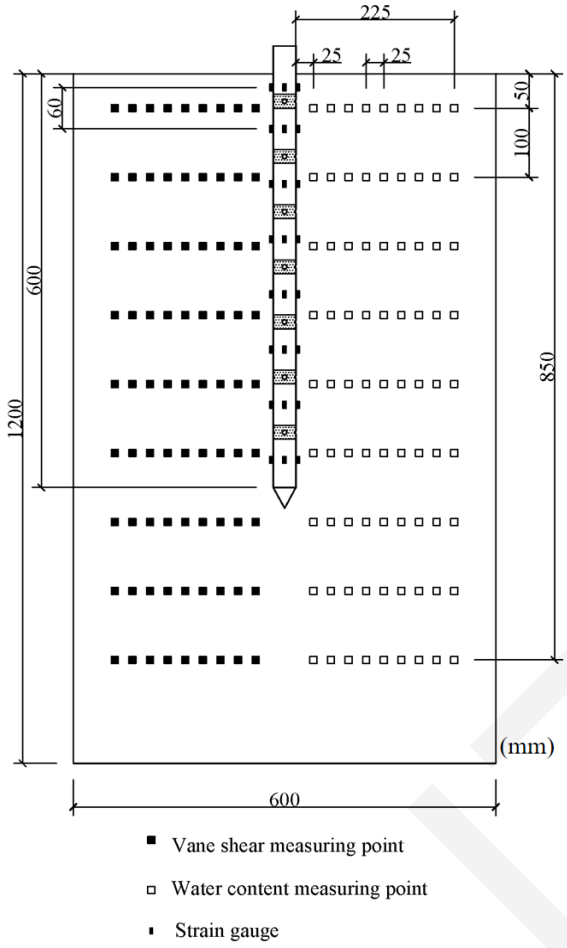


Fig. 4 Distribution of measuring points

Fig. 5 Vane shear instrument

Fig. 6 Static load test equipment

No.	Type of pile	Soil state	Working condition
1	Pipe pile	Undisturbed soil	Standing
2	Pipe pile	Remolded soil	Standing
3	Perforated pile	Remolded soil	Standing
4	Perforated pile	Remolded soil	Vacuum
5	Drainage pipe pile	Remolded soil	Standing
6	Drainage pipe pile	Remolded soil	Vacuum

Table 2 Grouping of the tests

Test Results and Analysis

■ Relationship between Pile Head Displacement and Vertical Load

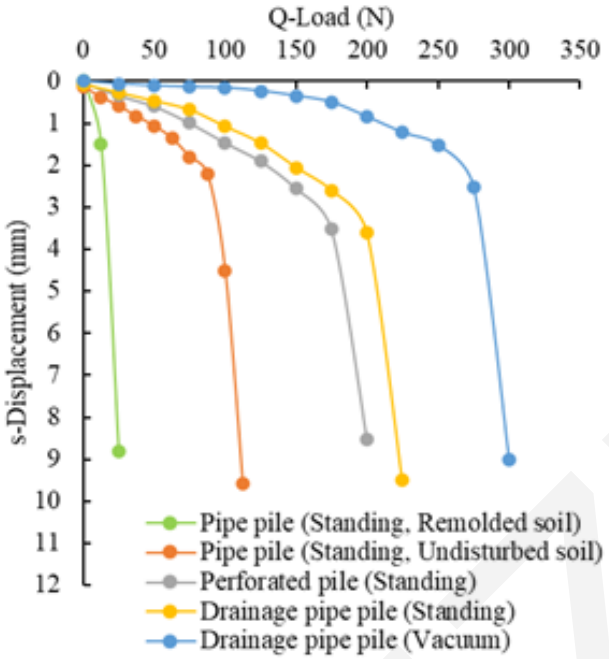
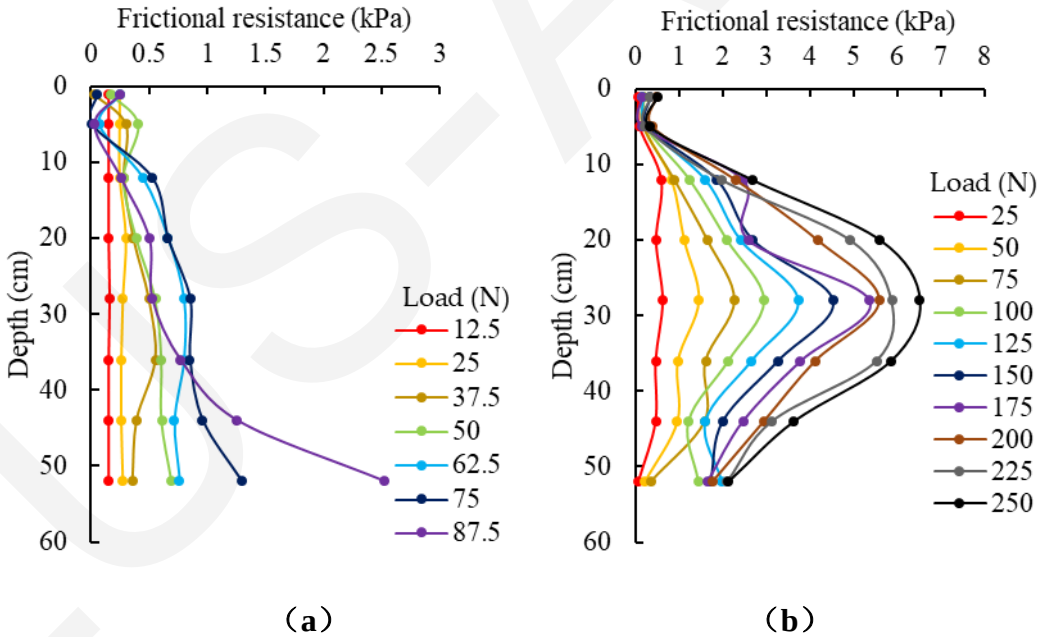


Fig. 7 Load-settlement curves for piles

■ Pile side friction



（a） （b）

Fig. 8 (a) Pipe pile (Standing, Undisturbed soil) Frictional resistance (b) Drainage pipe pile (Vacuum) Frictional resistance

The frictional resistance of the drainage pipe pile (Vacuum) was large in the middle and small at each end along the depth direction. It may be that vacuum consolidation had more effect in the middle of the pile, making the soil around the pile more compact.

Test Results and Analysis

■Water content / Vane shear strength distribution

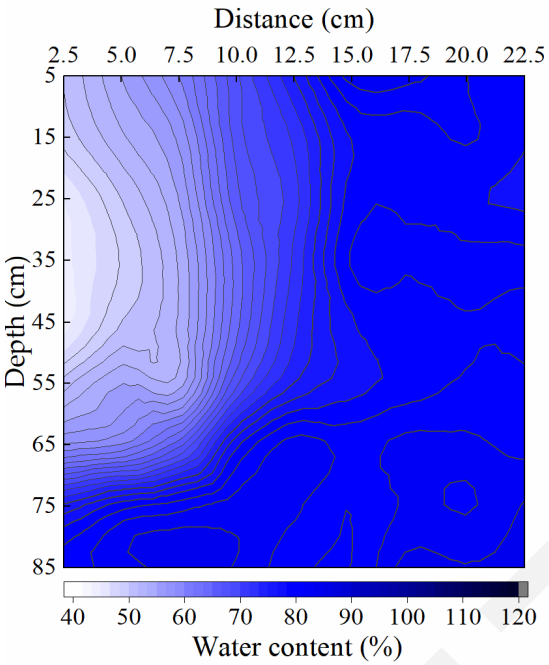


Fig. 9 Water content cloud chart of the drainage pipe pile (Vacuum)

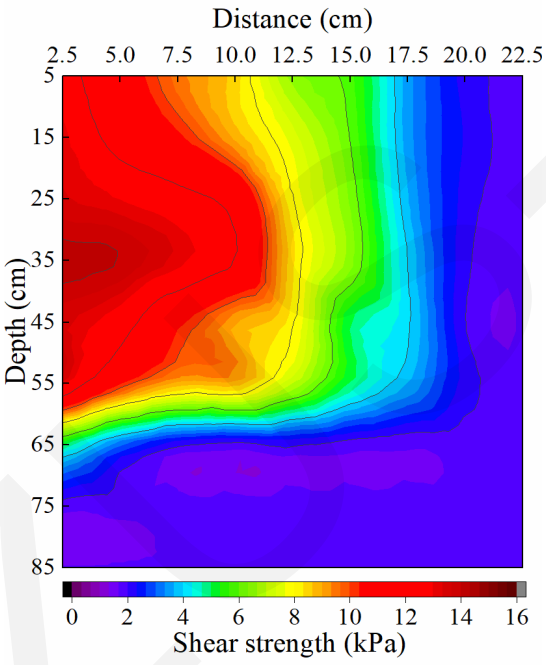


Fig. 10 Shear strength cloud chart of the drainage pipe pile (Vacuum)

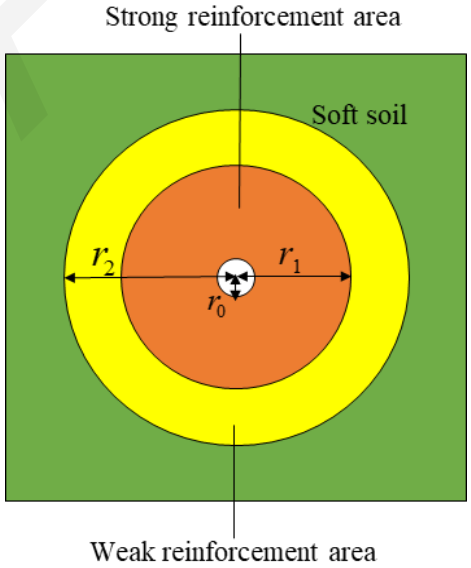


Fig. 11 Schematic diagram of reinforcement area

Conclusions

(1) The drainage pipe pile (Vacuum) showed no silting. According to the static load laboratory test of a single pile, the bearing capacity of the drainage pipe pile (Vacuum) was increased to 271.5 N, compared with 89.5 N of the pipe pile (considering the influence of pile top sealing on the degree of vacuum and the effect of pile spacing on drainage consolidation, this increase may be smaller in actual engineering).

(2) The maximum pile frictional resistance of the drainage pipe pile under vacuum condition was 3~4 times higher than that of the pipe pile. The distribution form of frictional resistance was changed. The pile frictional resistance was more developed in the middle and lower parts of the pile.

(3) For the drainage pipe pile (Vacuum), strong and weak reinforcement areas were defined according to the distribution of water content and shear strength of soil around the pile. The radius of the strong reinforcement area was positively correlated with the drainage volume. Using the shear strength at the junction of the two areas to estimate the ultimate bearing capacity of a single pile achieved good results.