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Modelling of static-drilled rooted pile construction

WEI Jiaqi, YIN Ji, LEI Dan, LI Xiang

SGIDI Engineering Consulting (Group) Co., Ltd.

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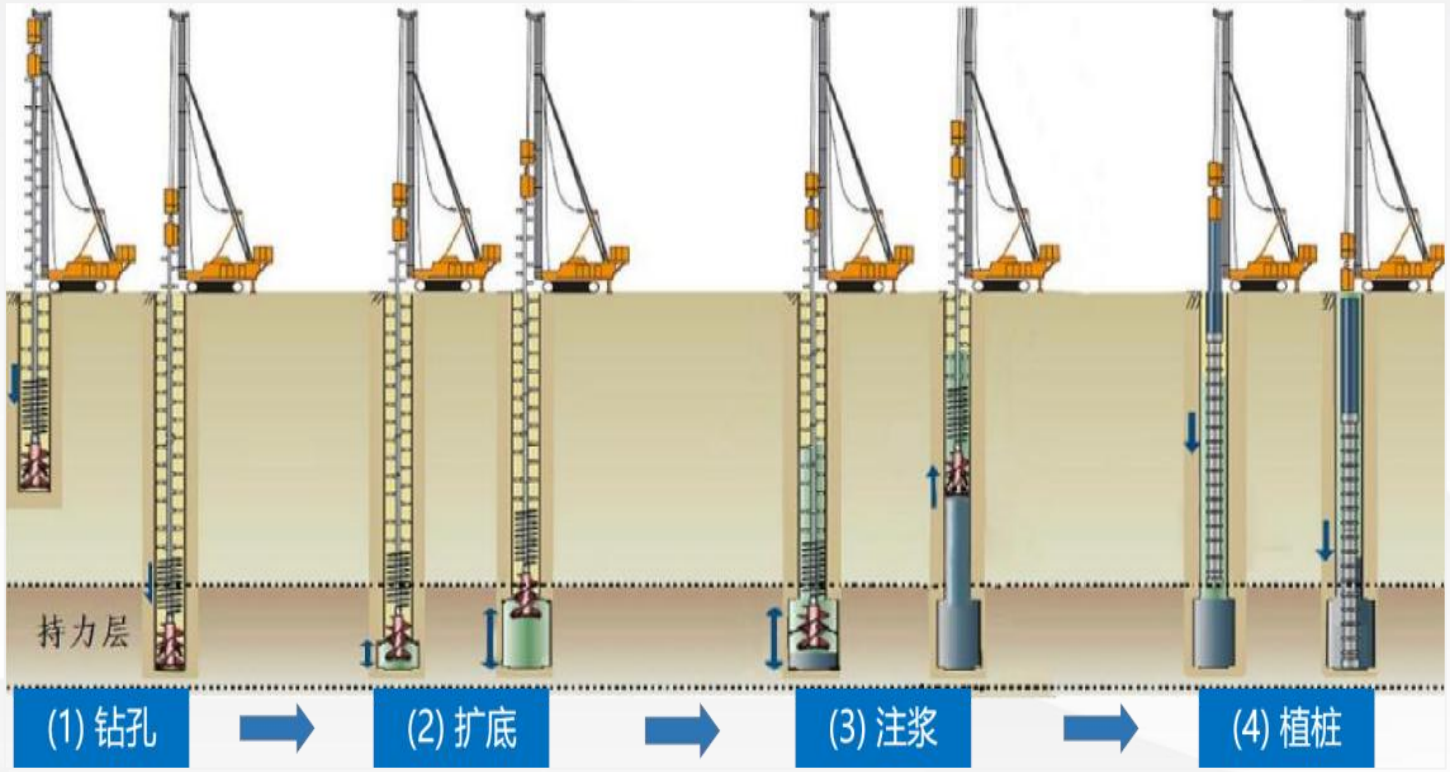
CONTENT

CONTENT

1 Introduction

- **Static-drilled rooted pile** is a new, green, non-displacement implanted precast pile foundation technology that combines the advantages of bored cast-in-place piles and precast piles



Drill **Under-ream** **Grout** **Insert piles**

1 Introduction

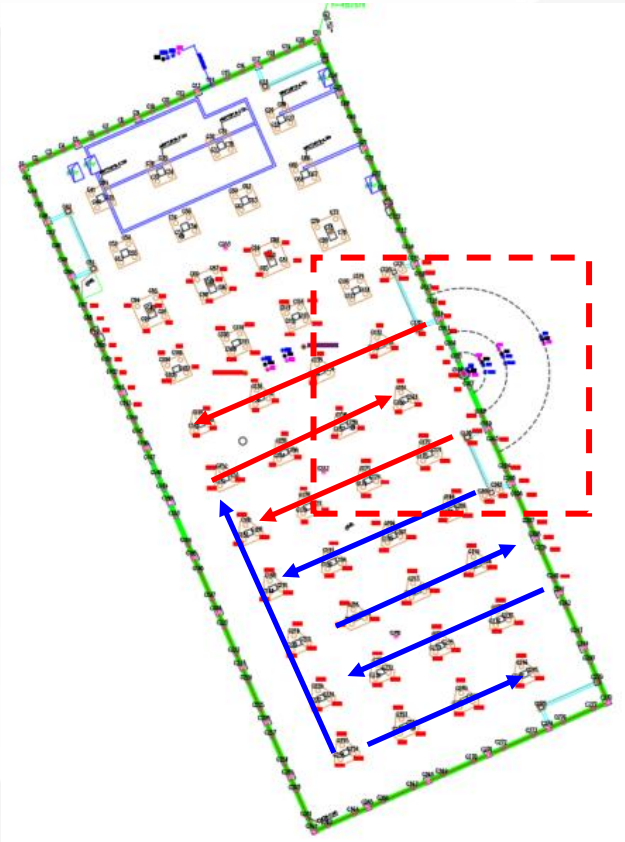
- **Despite being promoted as a non-displacement pile, the static-drilled rooted pile still inevitably causes some soil squeezing in practice during installation**

- **Thus, how do we model the construction process and its impact on nearby soil displacement?**

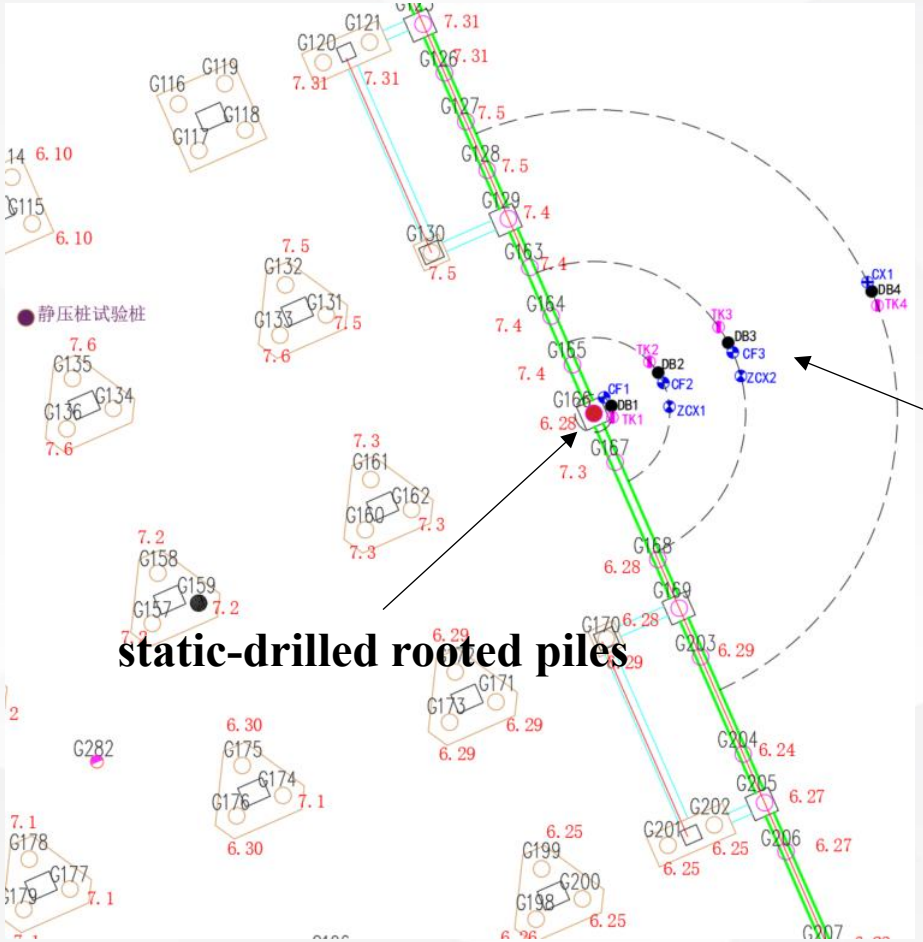
CONTENT

2.1 Field test

➢ Introduction



- construction sequence



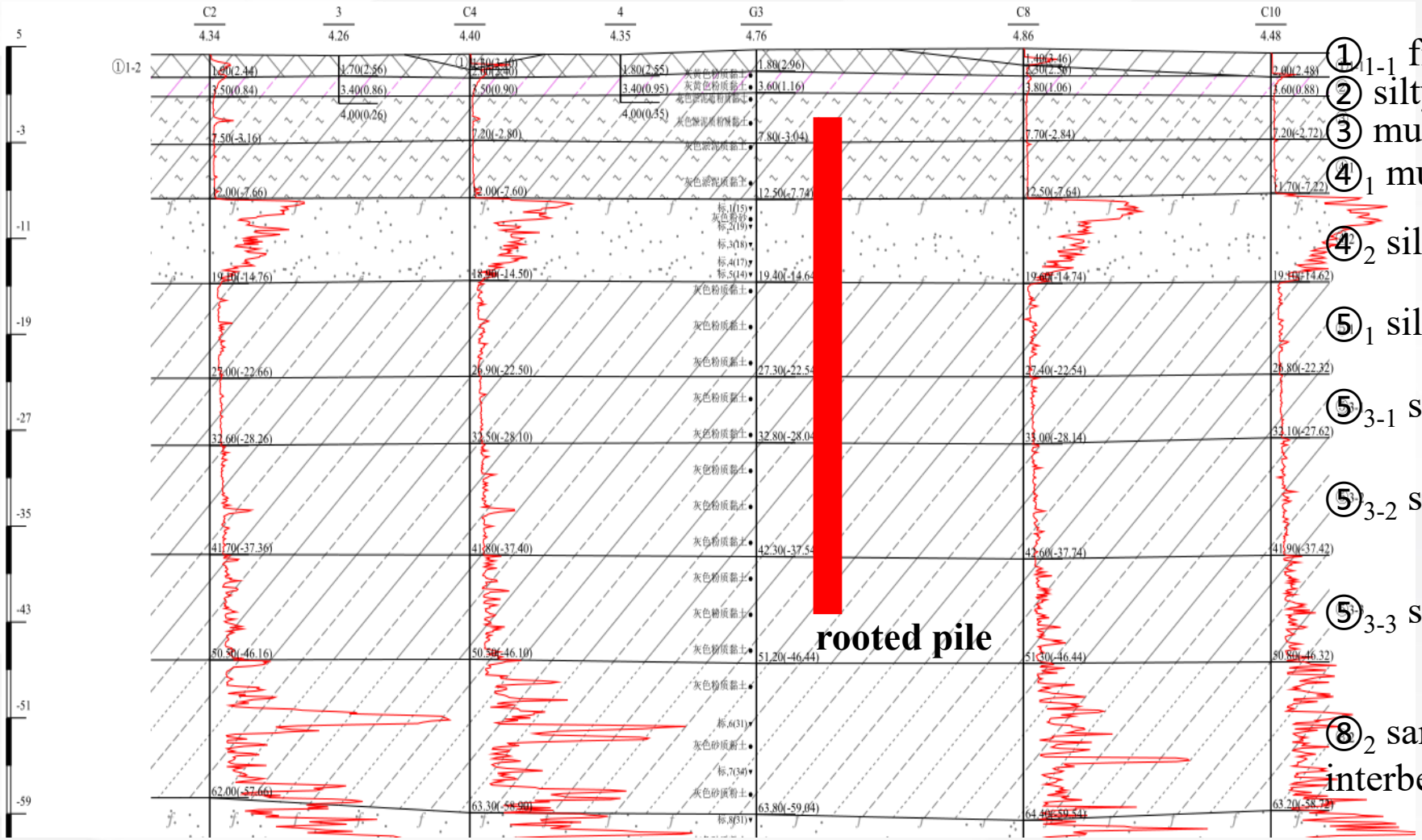
static-drilled rooted piles

Monitoring points, including inclinometer, settlement, pore water pressure, and earth pressure

- Project layout

2.1 Field test

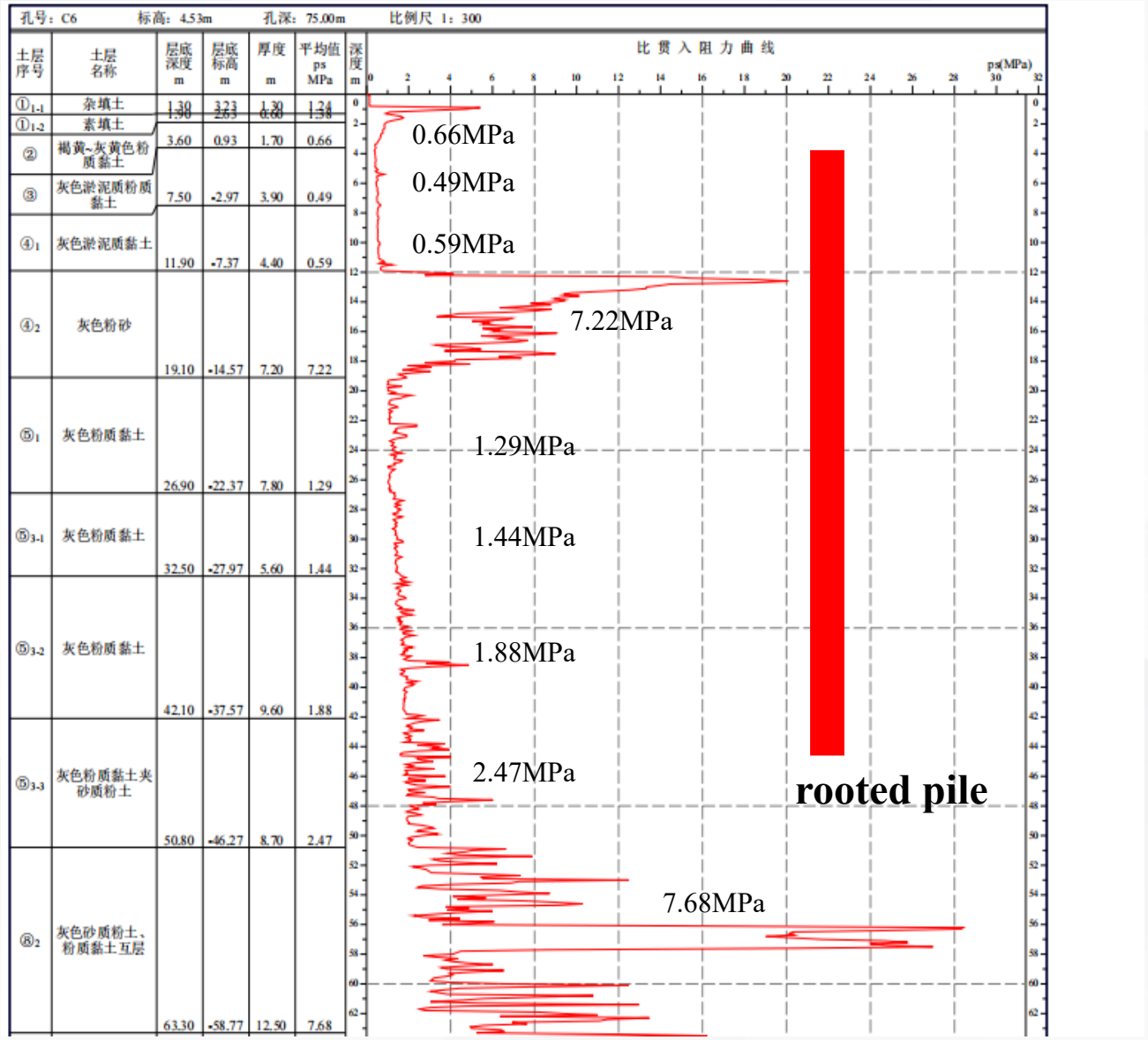
➢ Soil profile



2.1 Field test

➢ Typical CPT profile

①$_{1\text{-}1}$ fill
② silty clay
③ mucky silty clay
④$_1$ mucky clay
④$_2$ silty sand
⑤$_1$ silty clay
⑤$_{3\text{-}1}$ silty clay
⑤$_{3\text{-}2}$ silty clay
⑤$_{3\text{-}3}$ silty clay with sandy silt
⑧$_2$ sandy silt and silty clay interbedded

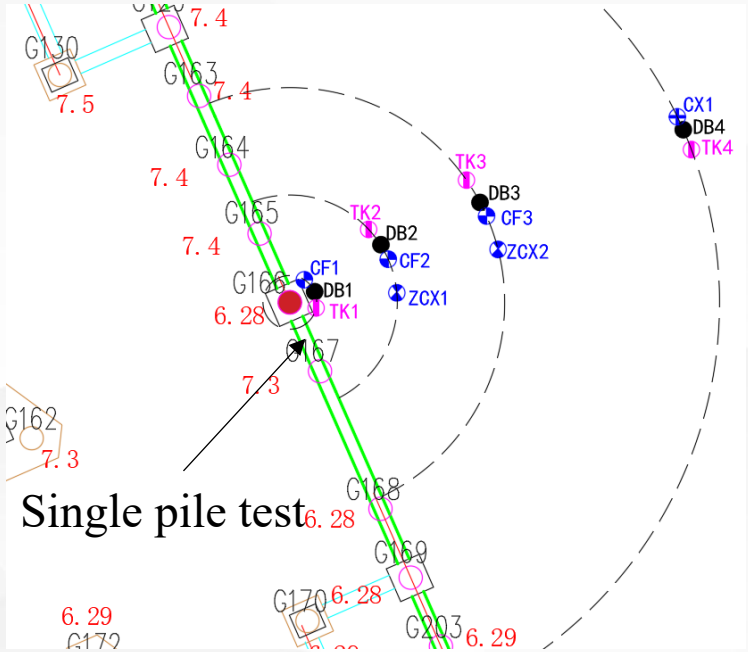


土层序号	土层名称	层底深度 m	层底标高 m	厚度 m	平均值 ps MPa
①$_{1\text{-}1}$	杂填土	1.30	3.23	1.30	1.24
①$_{1\text{-}2}$	素填土	1.98	2.55	0.68	1.58
②	褐黄~灰黄色粉质黏土	3.60	0.93	1.70	0.66
③	灰色淤泥质粉质黏土	7.50	-2.97	3.90	0.49
④$_1$	灰色淤泥质黏土	11.90	-7.37	4.40	0.59
④$_2$	灰色粉砂	19.10	-14.57	7.20	7.22
⑤$_1$	灰色粉质黏土	26.90	-22.37	7.80	1.29
⑤$_{3\text{-}1}$	灰色粉质黏土	32.50	-27.97	5.60	1.44
⑤$_{3\text{-}2}$	灰色粉质黏土	42.10	-37.57	9.60	1.88
⑤$_{3\text{-}3}$	灰色粉质黏土夹砂质粉土	50.80	-46.27	8.70	2.47
⑧$_2$	灰色砂质粉土、粉质黏土互层	63.30	-58.77	12.50	7.68

2.1 Field test

➢ Typical construction process—taking the single pile test as an example

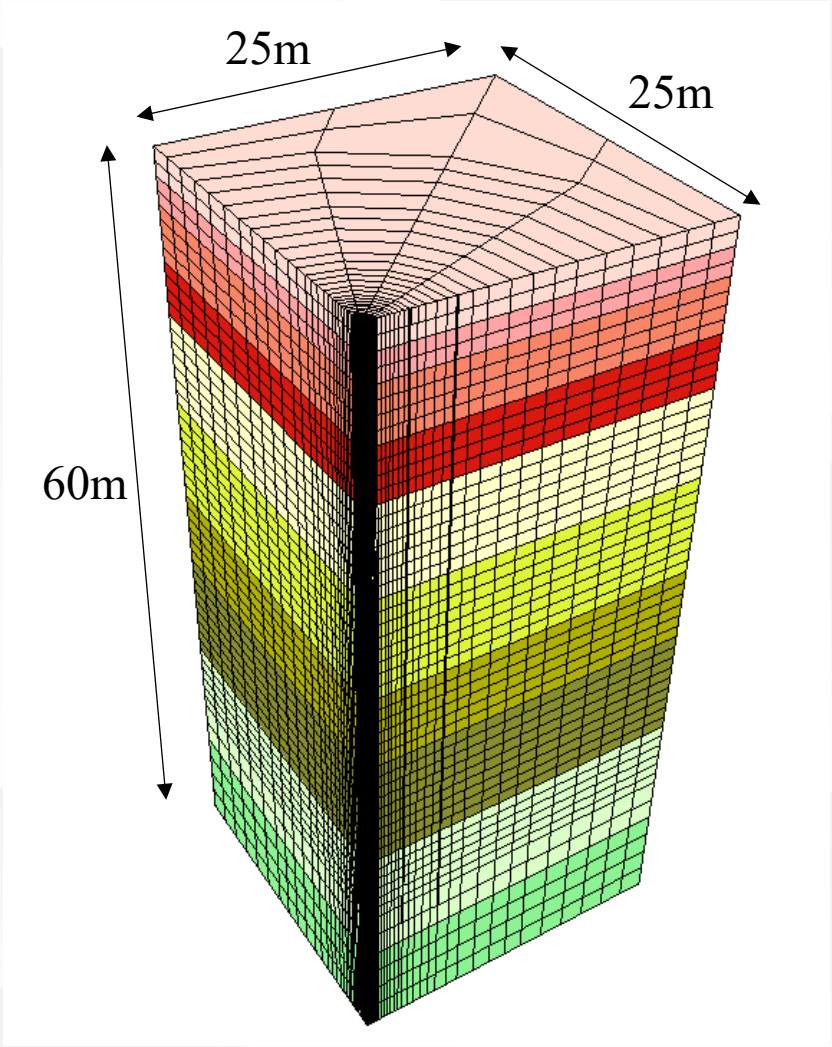
Process	Time
Drilling (D_1=750mm)	8:25~9:05
Grouting	9:50~10:20
Pile installation (D=600mm)	10:30~11:00

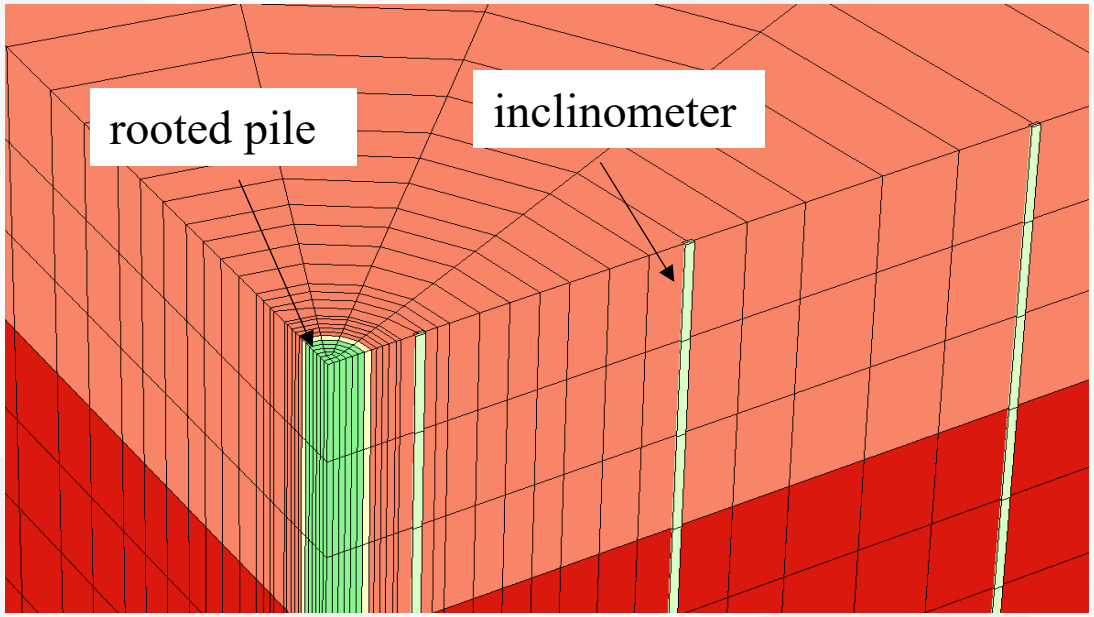


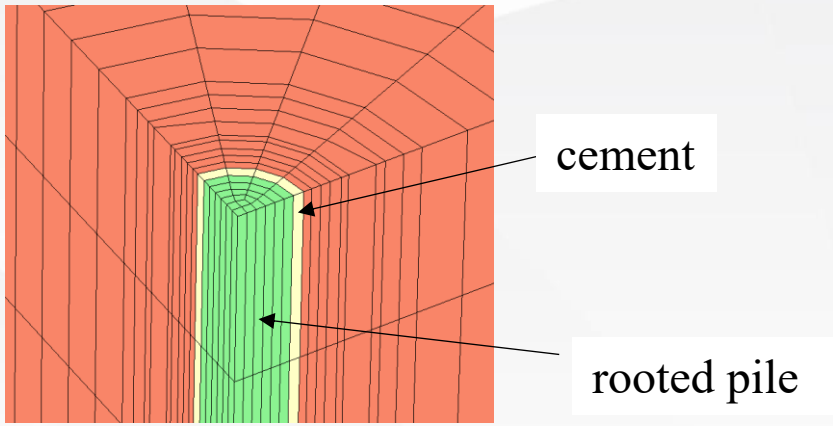
Single pile test

2.2 Numerical model

➢ **Typical numerical model for the single pile**

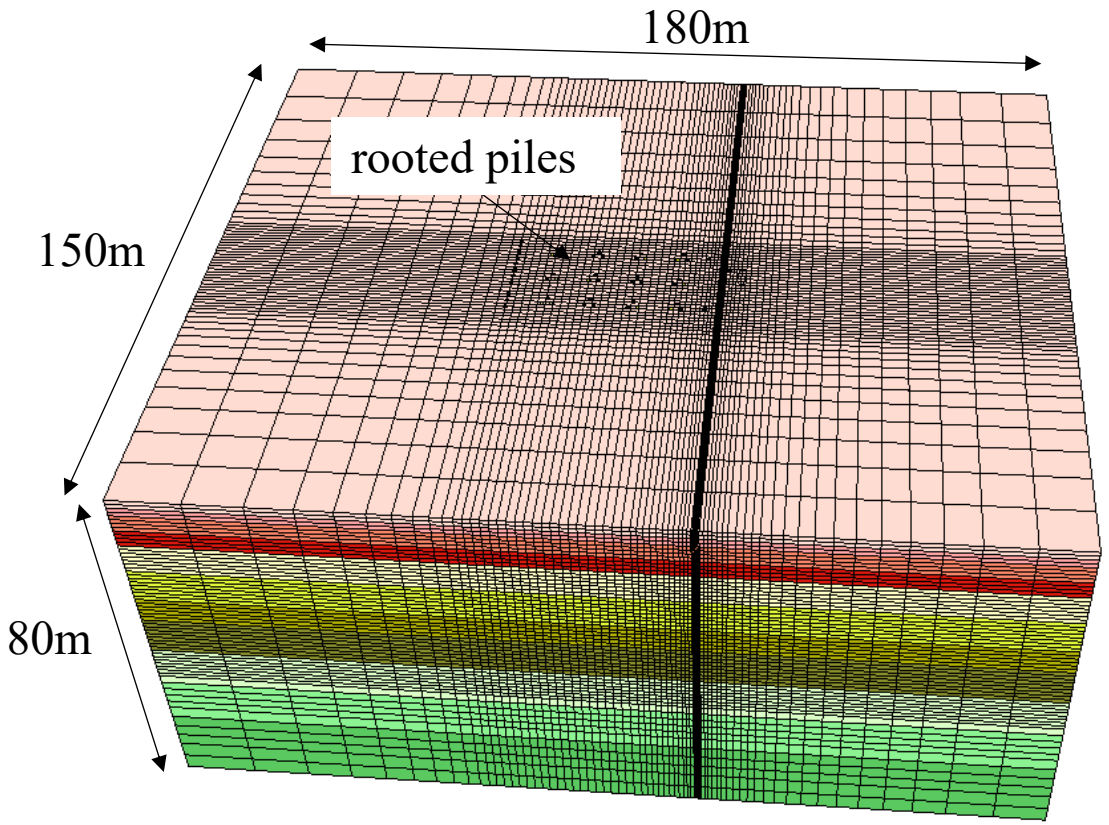


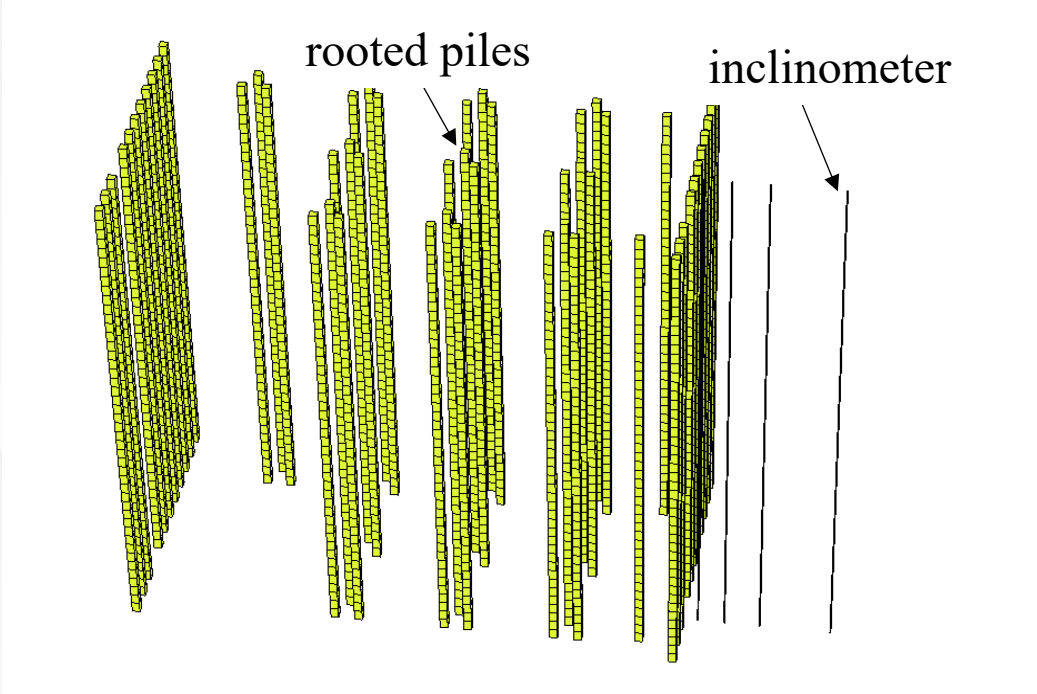




2.2 Numerical model

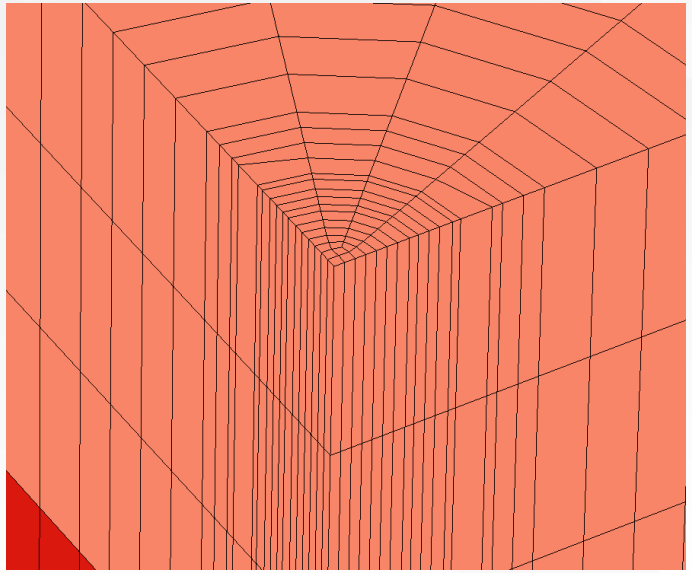
➢ **Typical numerical model for pile groups**



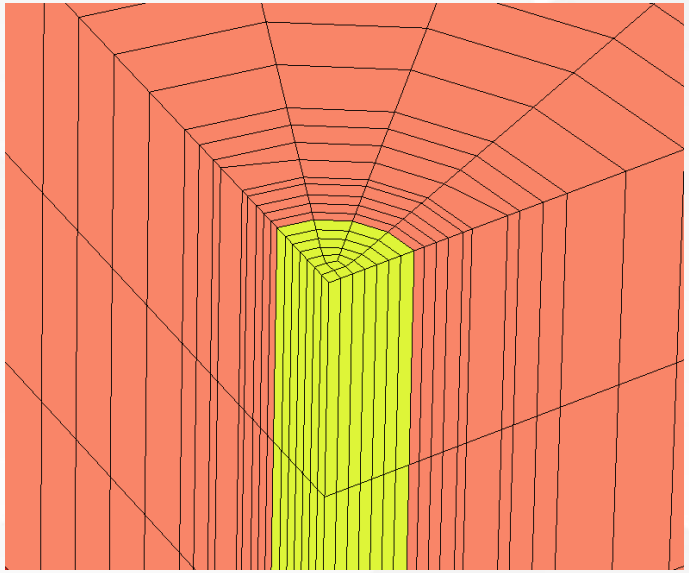


2.2 Numerical model

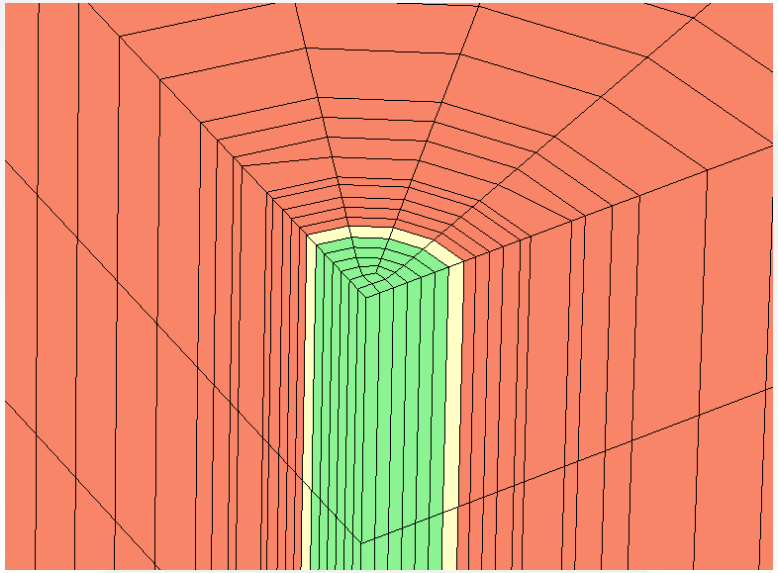
➢ Calculation condition



- initial ground stress generation



- drilling and grouting



- pile installation

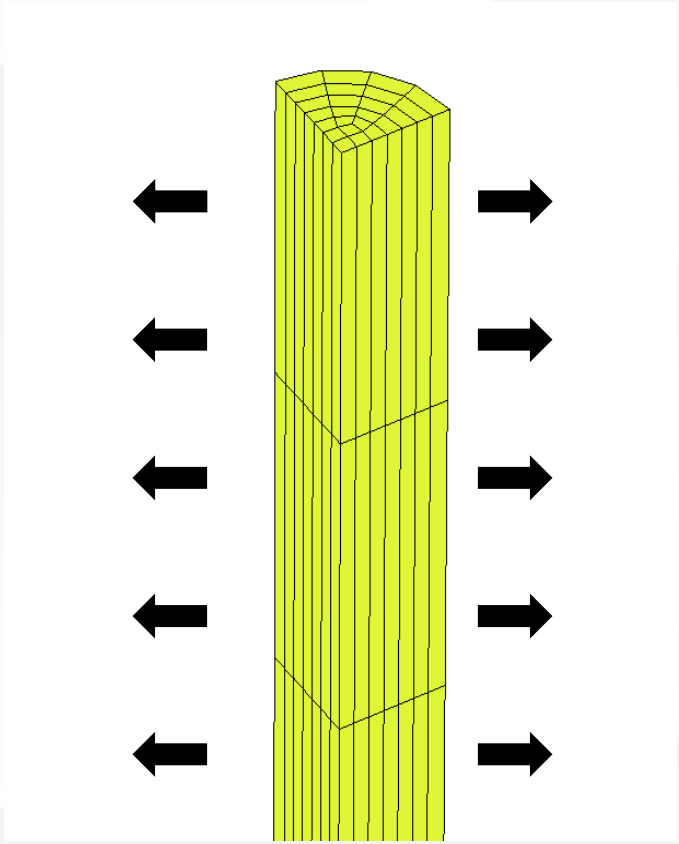
2.2 Numerical model

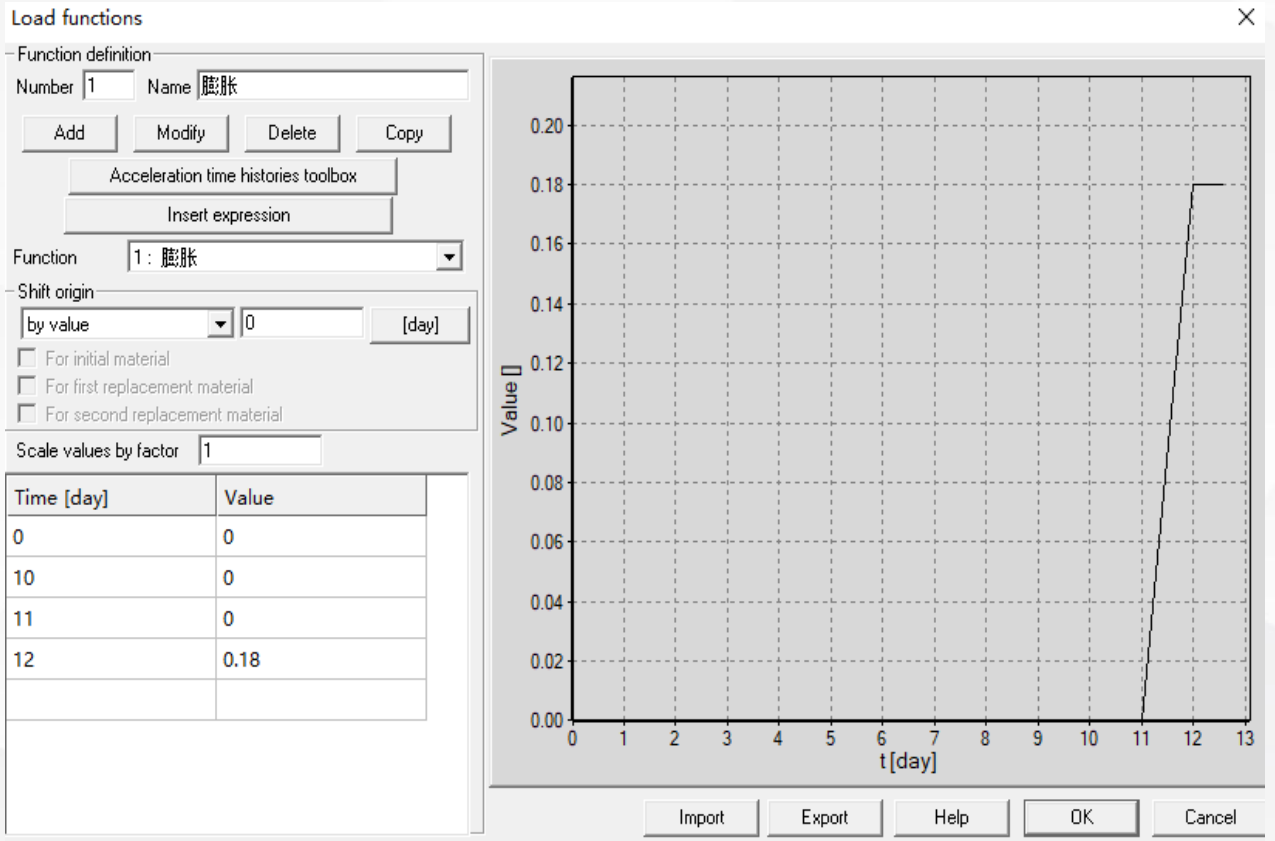
➢ Parameters of the soil constitutive model (HS-small strain model)

Soil	unit weight (kN/m^3)	water content (%)	φ(°)	c(kPa)	E_{50}(MPa)	E_{ur}(MPa)	E_0(MPa)
①$_{1\text{-}1}$ fill	18	30	24	10	1.7	8.7	70
② silty clay	19	28.3	28	8	2.4	12.2	98
③ mucky silty clay	17.6	40.4	24	10	1.6	8.2	65.8
④$_1$ mucky clay	17	49.5	22	10	1.7	8.9	71.4
④$_2$ silty sand	19.1	24.5	29	5	21.5	107.9	863.8
⑤$_1$ silty clay	18	34.7	26	10	3.8	19	152.6
⑤$_{3\text{-}1}$ silty clay	18.1	34.1	27	15	4.4	22.2	177.8
⑤$_{3\text{-}2}$ silty clay	18.2	33.7	28	15	5.5	27.8	222.6
⑤$_{3\text{-}3}$ silty clay with sandy silt	18.4	32.3	29	15	7.9	39.7	317.8
⑧$_2$ sandy silt and silty clay interbedded	18.5	30.5	30	10	18.4	92.4	739.2

2.2 Numerical model

➢ Volumetric strain method

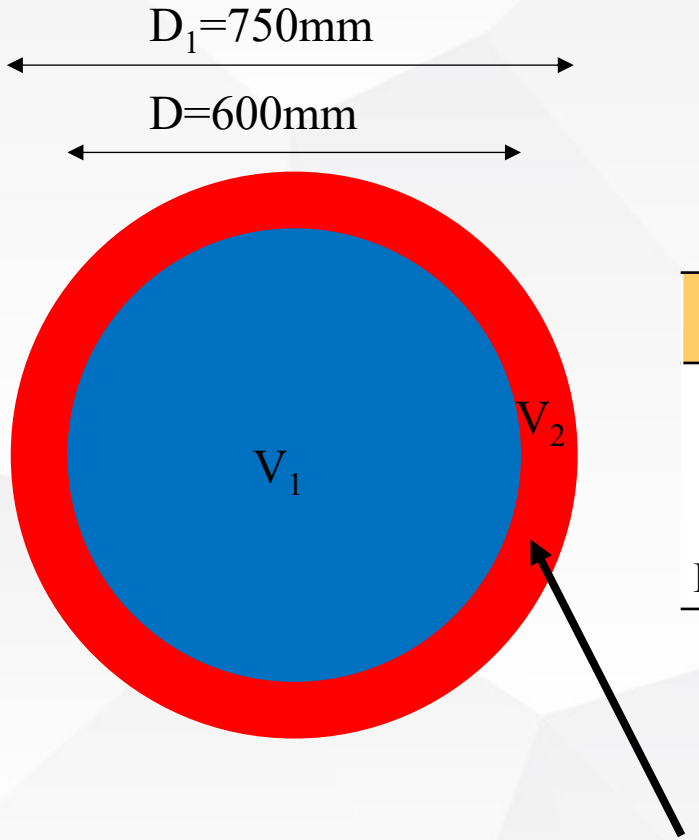




- Volumetric strain method was applied for simulating soil displacement during the construction of static drilling rooted piles, including drilling, grouting and pile installation

2.2 Numerical model

➢ Volumetric strain method



Process	Volumetric strain
Drilling and grouting	55%
Pile installation	15%

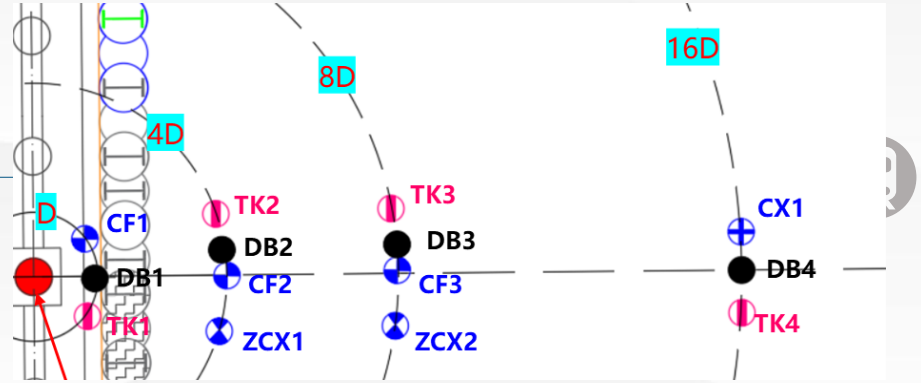
- The volumetric strain due to drilling and grouting was approximately 55%
- During pile installation, 15% of the extruded volume V_1 was applied to the outer soil element (V_2)

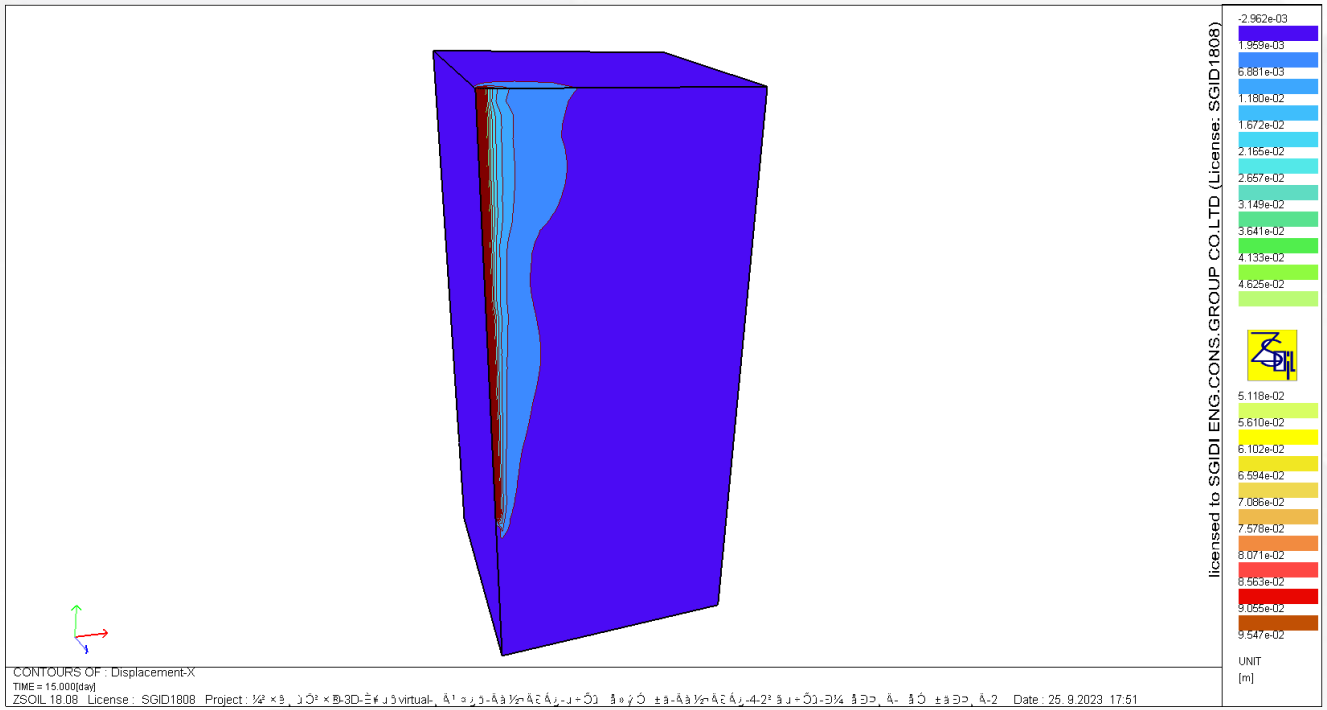
CONTENT

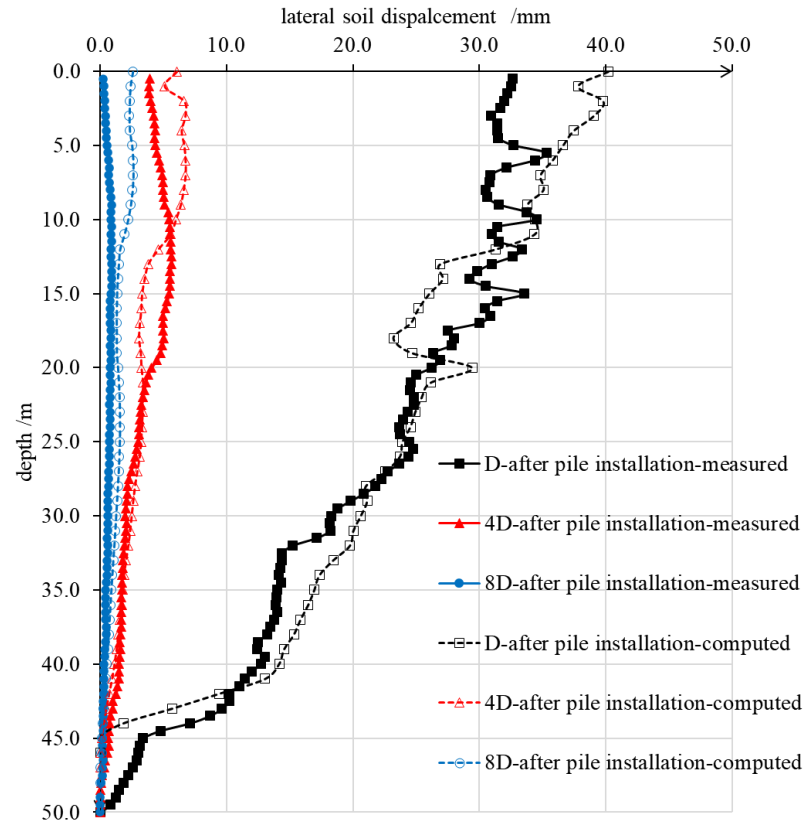
3 Numerical results

➢ Results for the single pile

☐ Soil lateral displacement





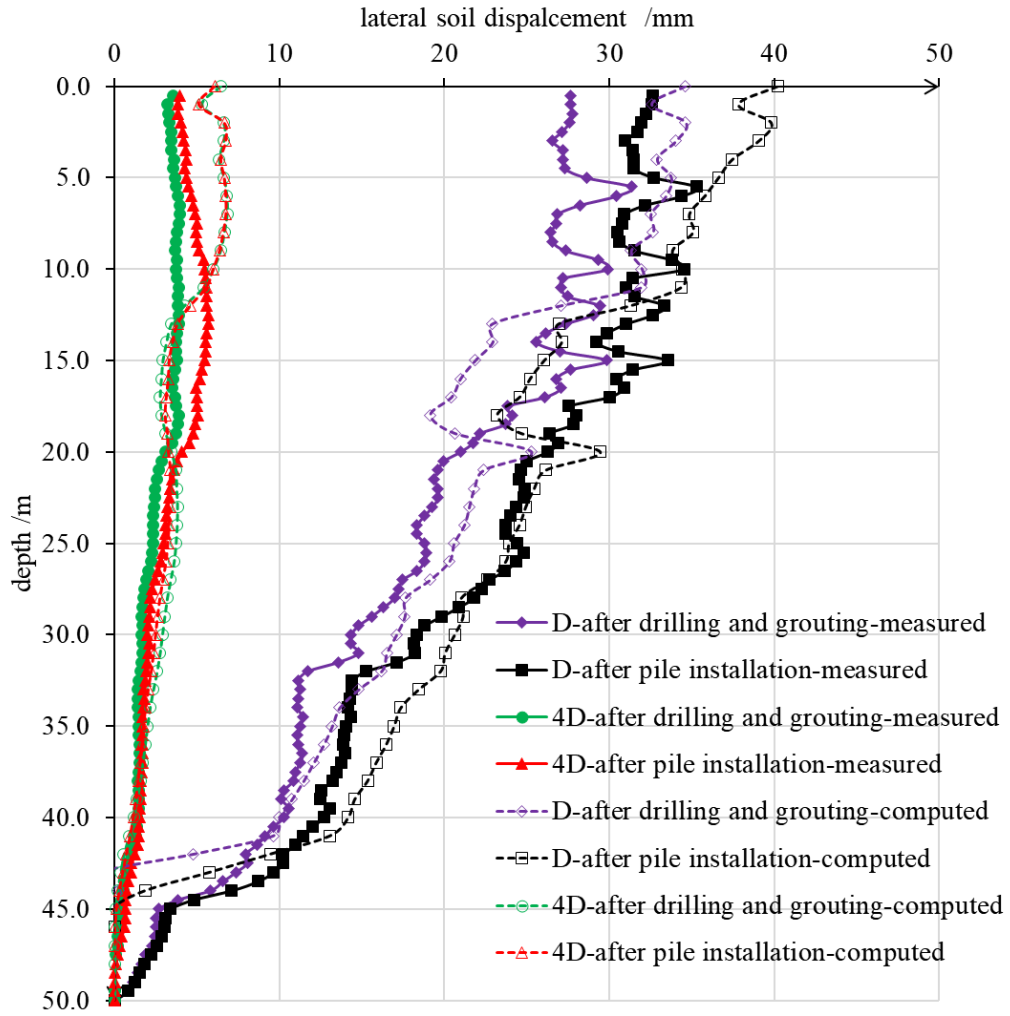


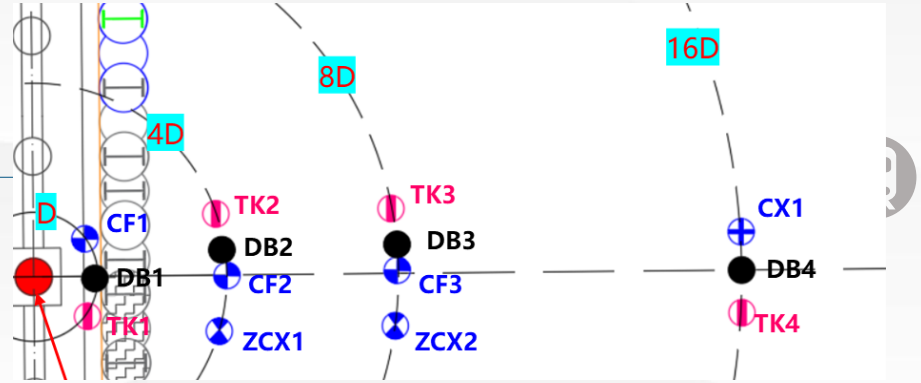
- The maximum soil lateral displacement was 35mm
- The calculated soil displacements agree well with the measured data
- Lateral displacements outside 8D were small (D was the pile diameter), thus the influence zone was about 8D

3 Numerical results

➢ Results for the single pile

☐ Soil lateral displacement



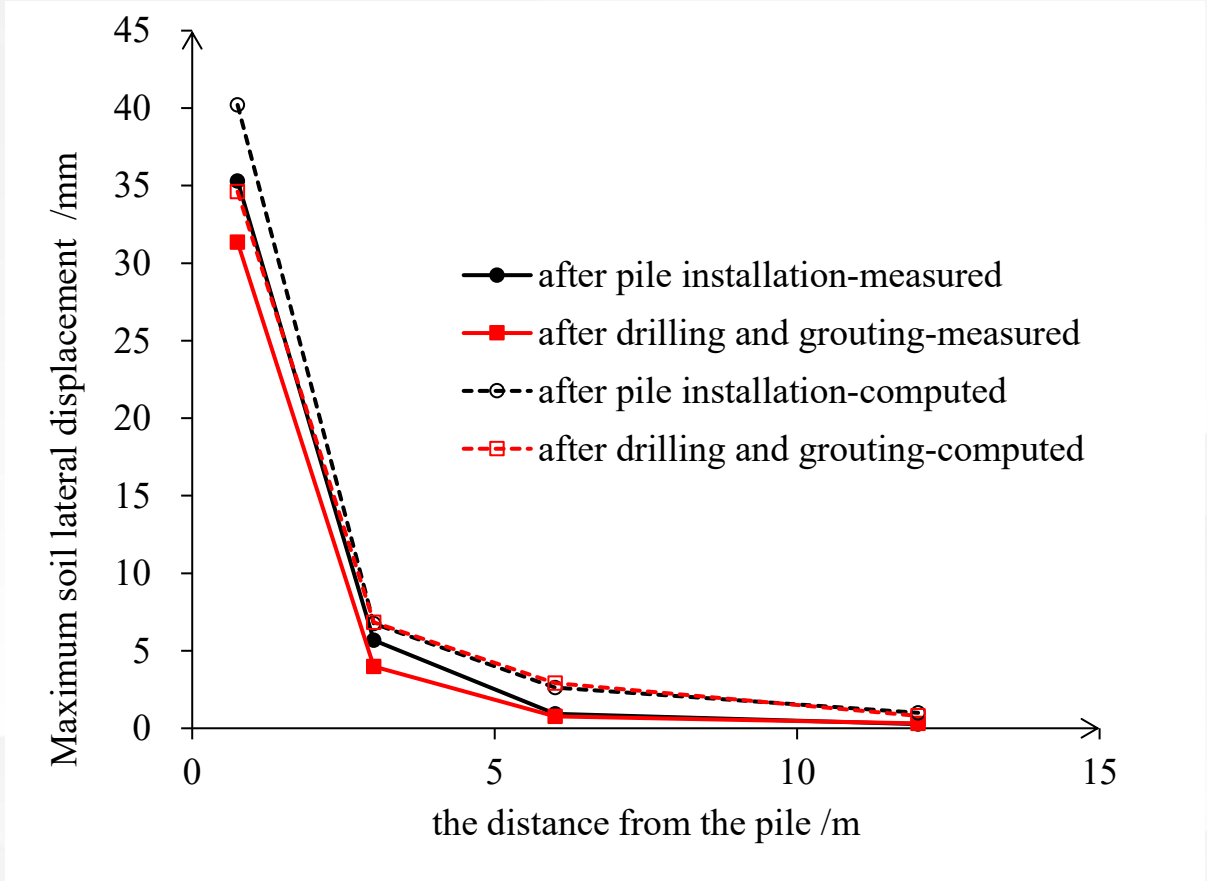


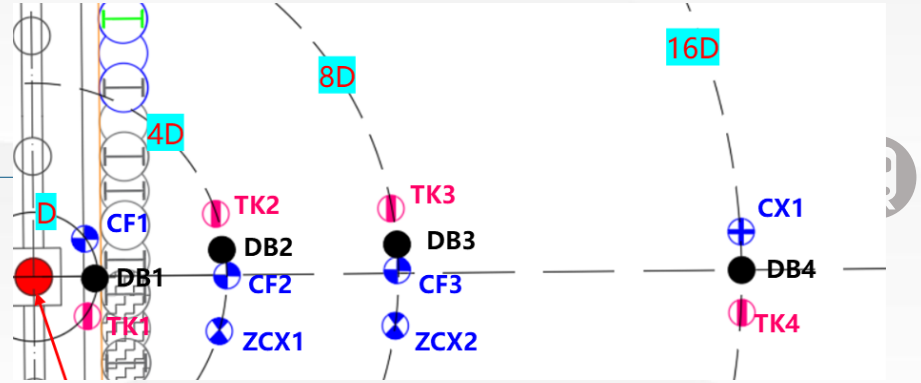
- According to the measured lateral displacement curves, the major deformation occurred during drilling and grouting, accounting for about 80-90% of the total
- The calculated and measured lateral displacement patterns were in good agreement, which demonstrates the feasibility of using the volumetric strain method to simulate the construction of the static-drilled rooted pile

3 Numerical results

➢ Results for the single pile

☐ Soil lateral displacement



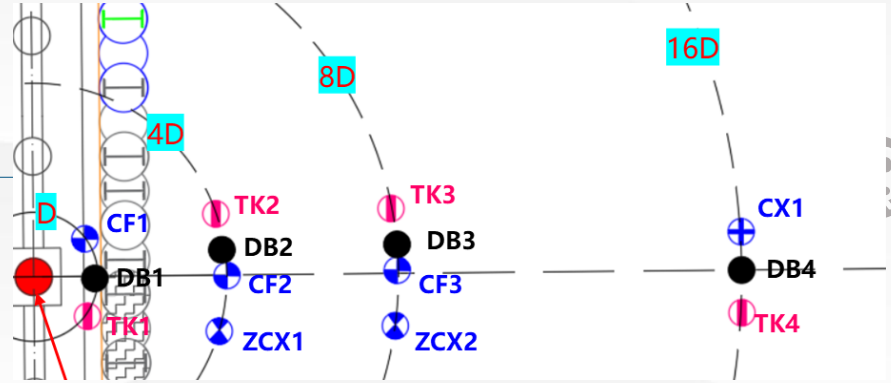


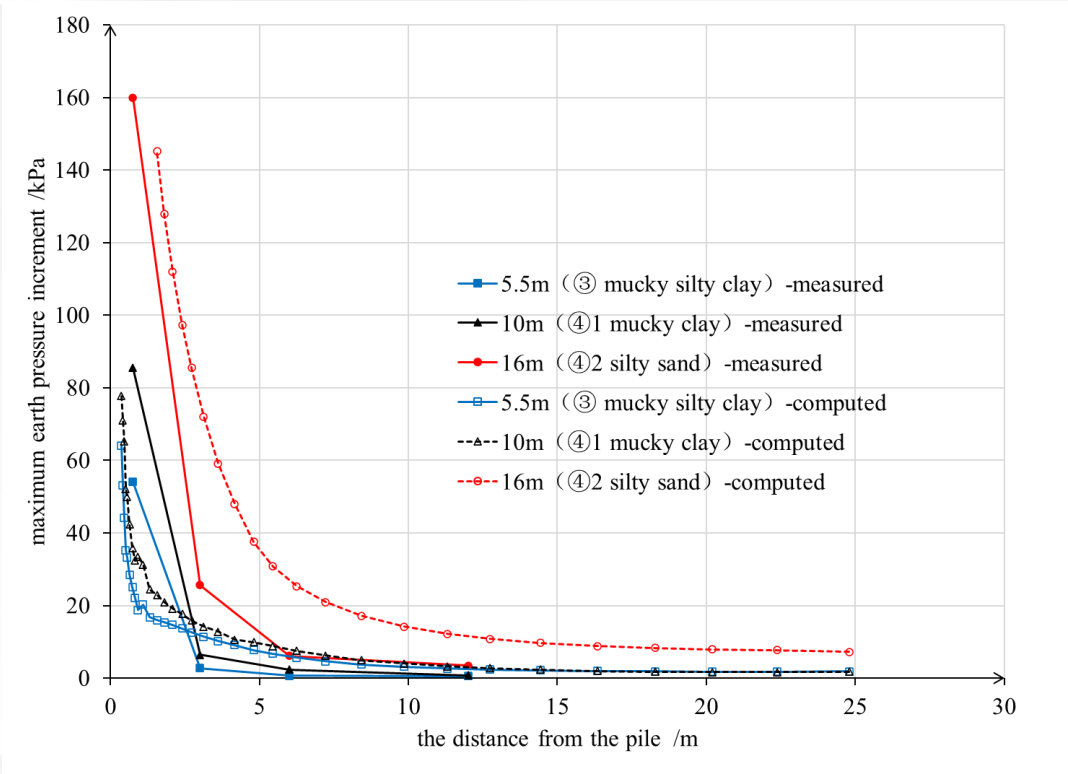
- As the distance from the pile increased, the maximum soil lateral displacement decreased exponentially
- The influence zone was 6m (about 8D)
- The calculated and measured lateral displacement patterns were in good agreement

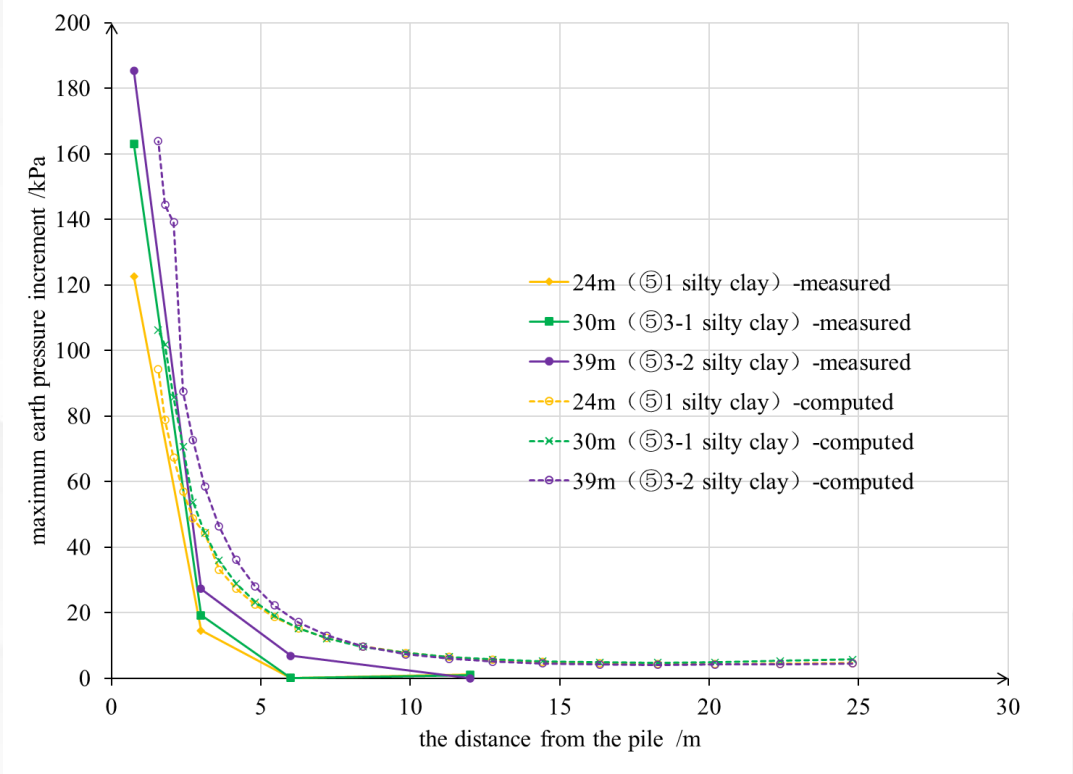
3 Numerical results

➢ Results for the single pile

☐ Earth pressure increment





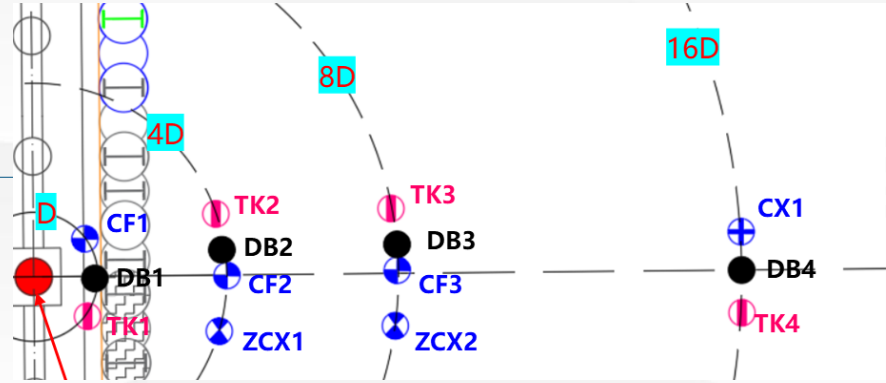


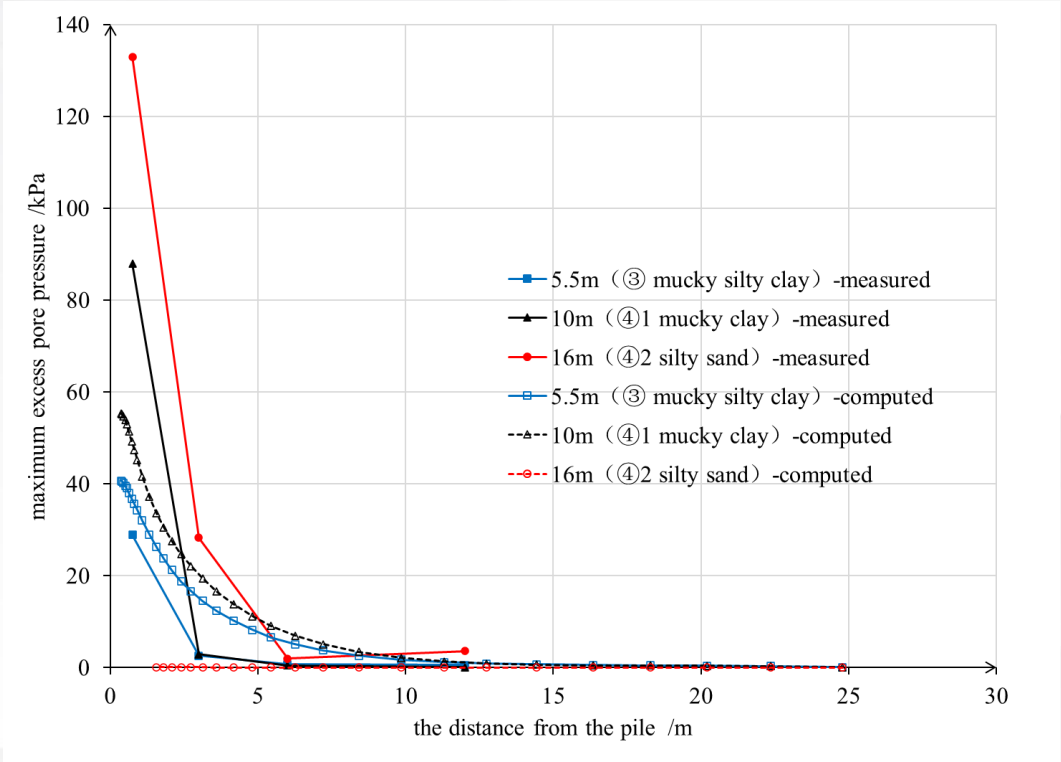
- Due to the application of the volumetric strain method, the earth pressure increment showed some deviation from the measured values within 3 m (4D); Measured maximum earth pressure increment was 186kPa
- Beyond 3m (4D), the calculated results were relatively close to the measured results in both magnitude and trend

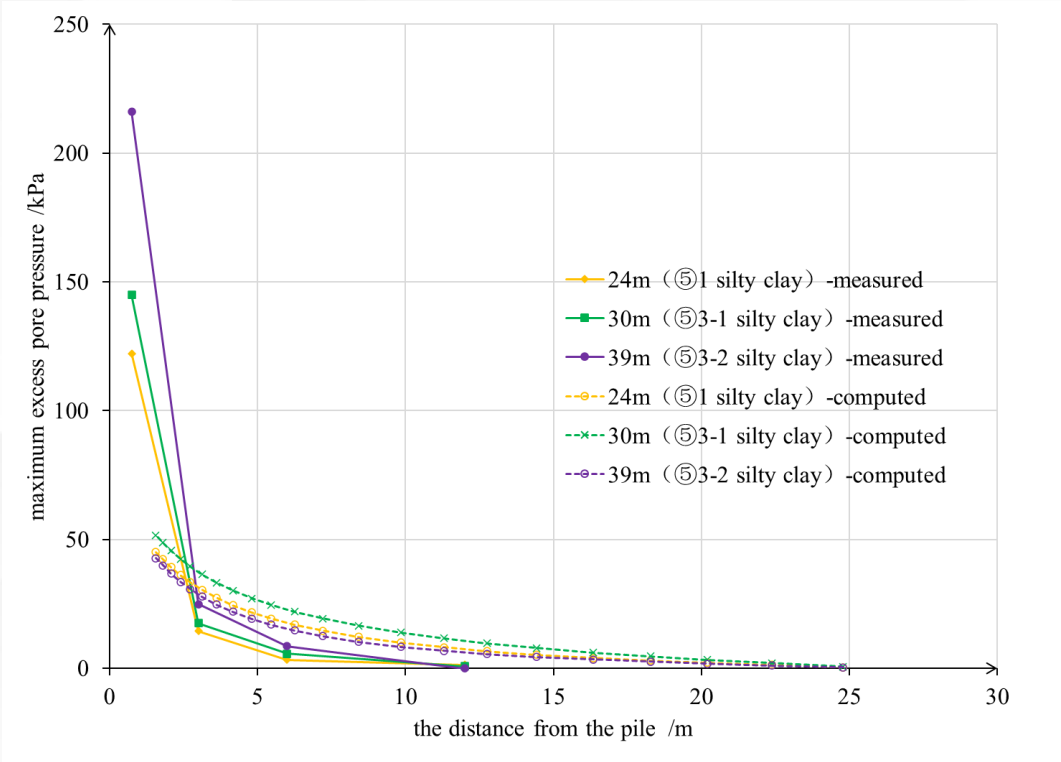
3 Numerical results

➢ Results for the single pile

☐ Excess pore pressure







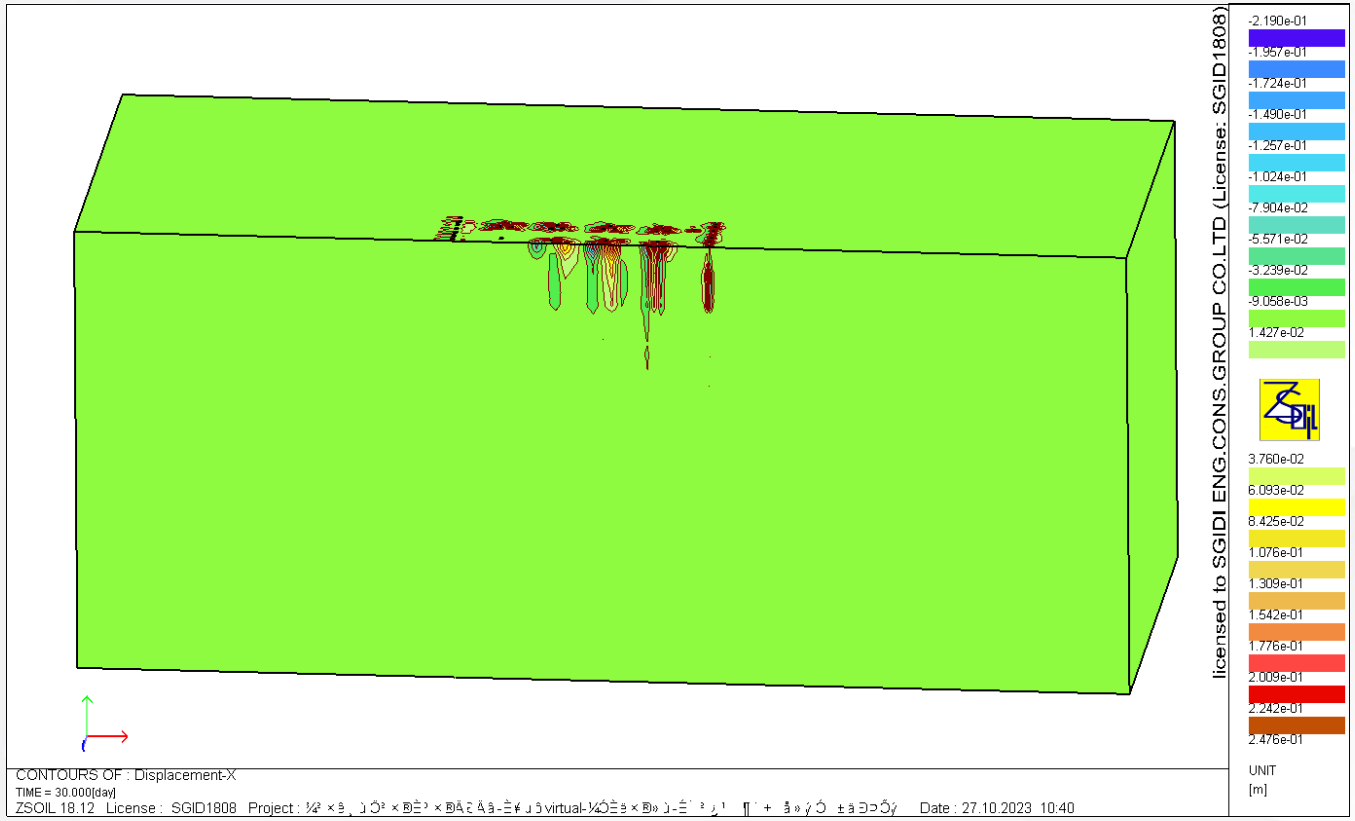
- Beyond 5m (6.6D), the calculated excess pore water pressure agreed with the measured results, but showed some deviation
- Measured maximum excess pore pressure was 216kPa
- For ④2 sandy silt, the calculated excess pore water pressure differed from the measured values, which can be attributed to its permeability

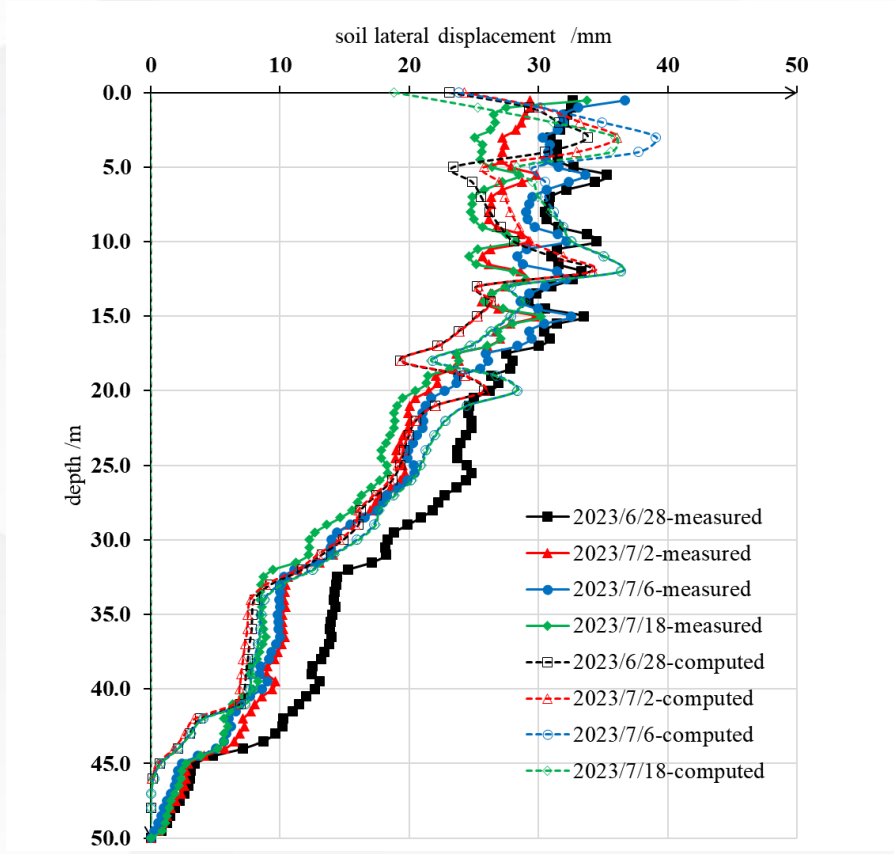
3 Numerical results

➢ Results for pile groups

☐ Soil lateral displacement

The distance from the measured point to the pile was 0.75m



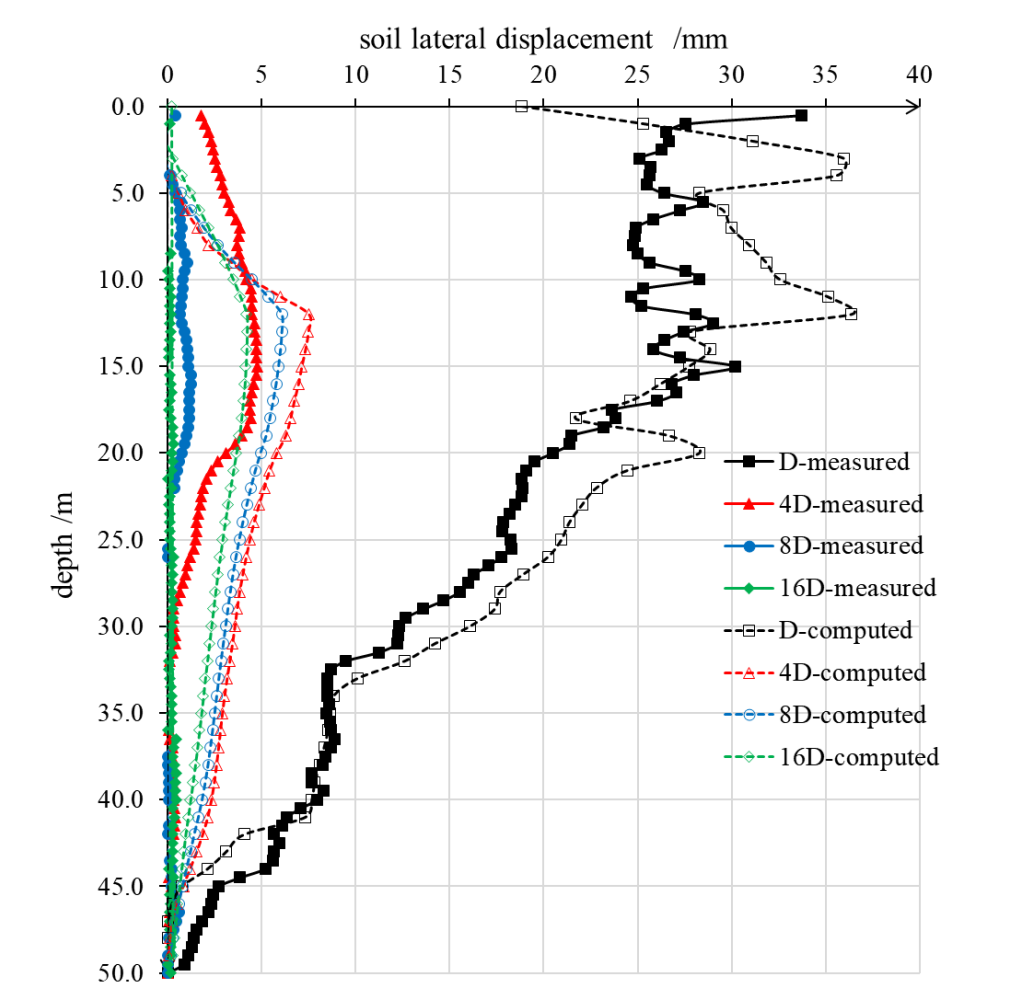


- The calculated and measured soil lateral displacement were generally close
- Maximum soil lateral displacement was 37mm

3 Numerical results

➢ Results for pile groups

☐ Soil lateral displacement



- The calculated values were larger than the measured ones, but overall they were close
- It is indicated that the volumetric strain method can be used to analyze the influence of stati-drilled rooted piles on adjacent soil and structures in practice

CONTENT

4 Conclusions

- The volumetric strain method with HS-small strain model can reasonably simulate the influence of the static-drilled rooted pile on soil and structures

- The maximum soil lateral displacement was 37mm during the construction of the pile groups

- The drilling and grouting stages are the dominant construction phases, contributing approximately 80–90% of the total lateral soil displacement, as confirmed by both field measurements and numerical simulations

THANK YOU