Consideration for End Shape of a Pile for Pre bored Pile Construction Method

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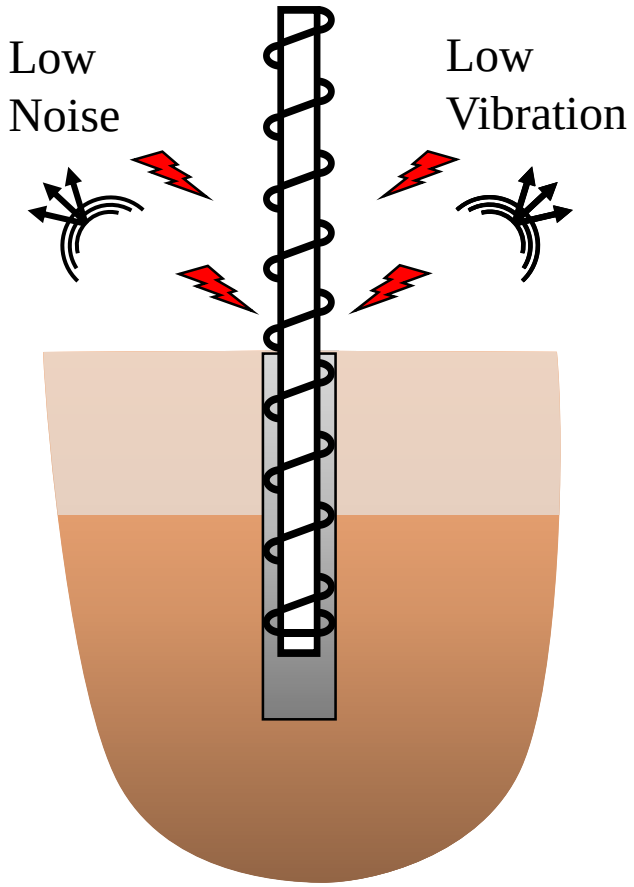
INTRODUCTION

- **The cement milk pile construction method is classified as the prebored pile construction method.**
- **The application number of this method has increased in Japanese urban areas because of the low construction noise and vibration.**
- **Recently, small size steel piles are often used for foundations of house or retaining wall.**

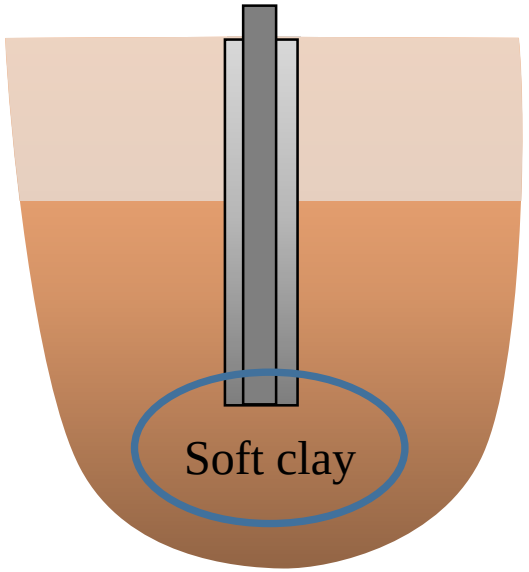
Retaining wall with small steel pile constructed by cement milk method



INTRODUCTION

- If the pile end is fixed in soft or medium clay, vertical resistance might decrease.
- Accordingly, it is important to ensure the stiffness of a consolidation of pile end.
- In this study, we propose to attach a holed disk plate to the pile end in order to improve the end bearing capacity of a small sized steel pipe pile.

Small sized steel pile with end disk plate



INTRODUCTION

Laboratory Experiments

We examine the characteristics of the end bearing capacity and the effectiveness of the end disk plate.

Design the End Disk Plate

The dimensions of the plate to apply to the cement milk method are discussed.

Loading Test in the Field

Actual size loading tests are performed to confirm the validity of the improved pile end.

LABORATORY EXPERIMENT

Test Pile

- A steel pipe is used as a test pile.
  - Diameter is 48.6 mm (*D*).
  - Length is 600 mm.
  - Embedment length(H) is 243 mm (5*D*).
- To eliminate the frictional resistance, the pile surface is coated with Teflon.

Test Tank

- A steel circular test tank is used.
  - Diameter is 650 mm.
  - Depth is 700 mm.

Model Ground

- No. 5 silica sand in dry condition is used.
- Model ground is prepared by the air pluviation technique with double nets for dispersion.
- The N-values of the pile end is N=2.

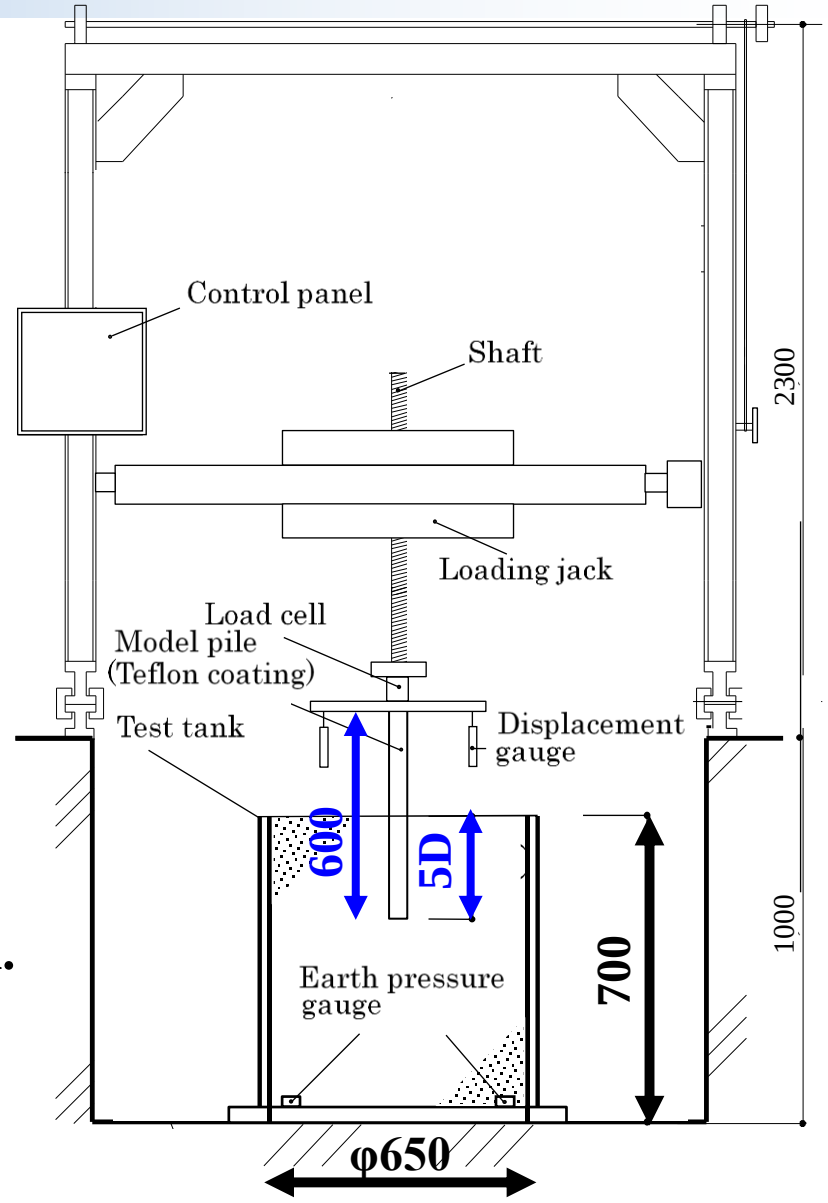
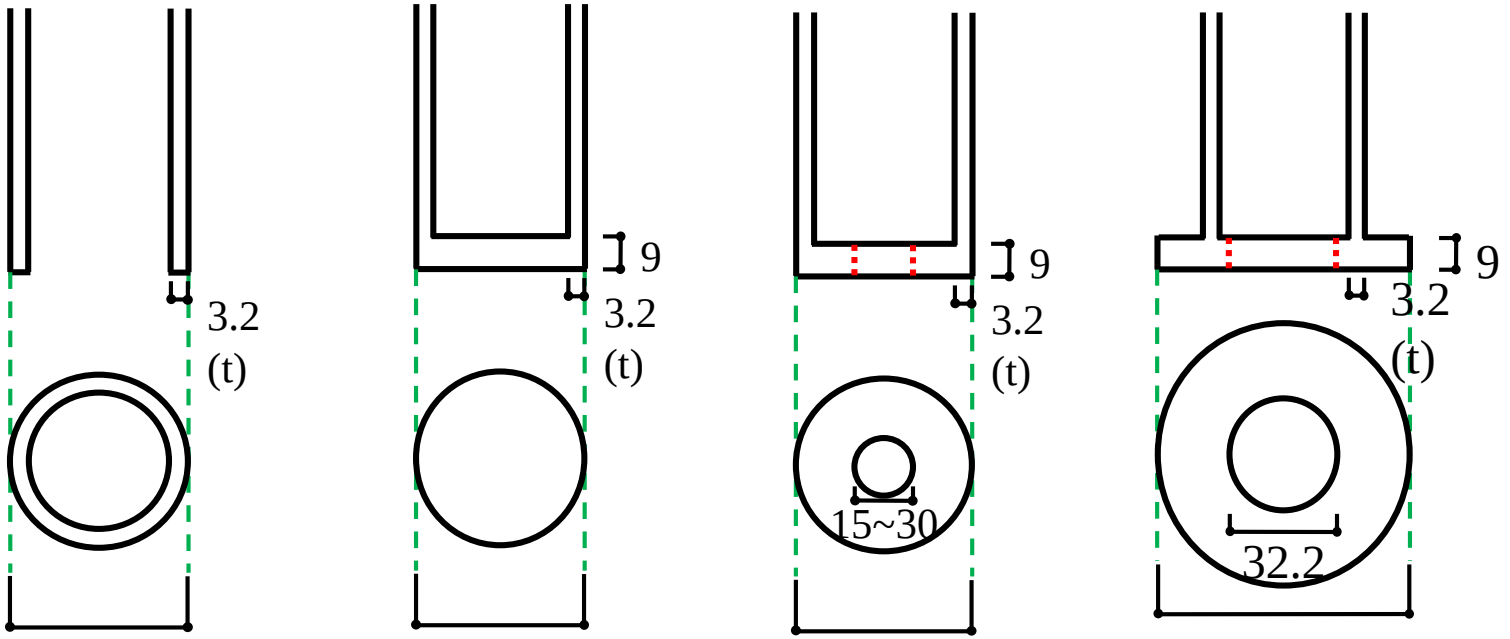


Fig. 3 Experimental apparatus

LABORATORY EXPERIMENT



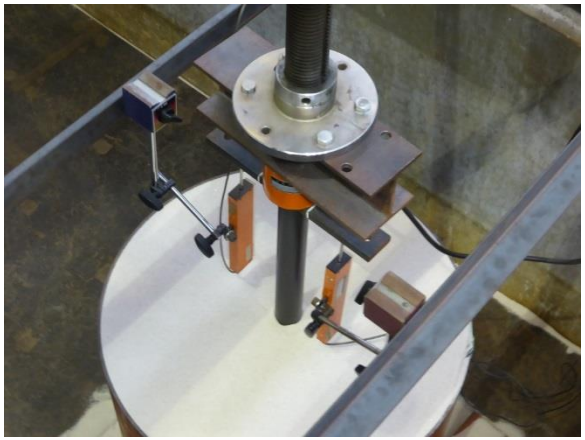
- **We performed 4 kinds of model tests.**
- **S-series : To discuss the influence of the pile end opening.**

  Opening diameters (D_o) are 15, 25 and 30 mm.
- **P-series : To investigate the effect of the pile end area.**

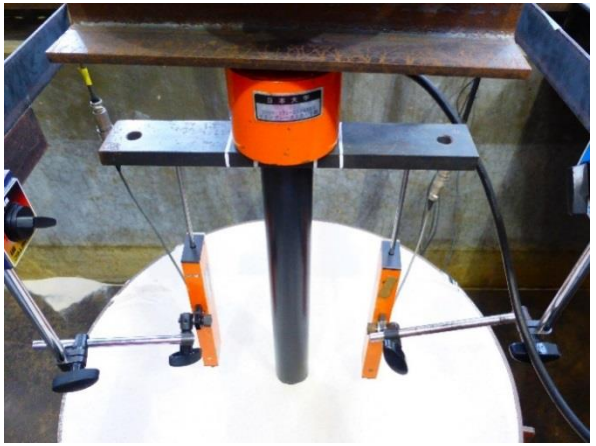
  External diameters (D_e) are 58.3, 67.6 and 75 mm.

LABORATORY EXPERIMENT

Pile tip (P-series)



Loading scene



Situation of the pile head

- For axial loading, we used displacement controlling type loading device.

Loading speed is 1 mm/min.

Measurement interval is 3 seconds.

- The resistance and the displacement of the pile end are almost equal the values of the pile head, because the length is short and the surface is coated by the Teflon.

Pile head load＝Pile end load

Pile head displacement＝ Pile end displacement

LABORATORY EXPERIMENT

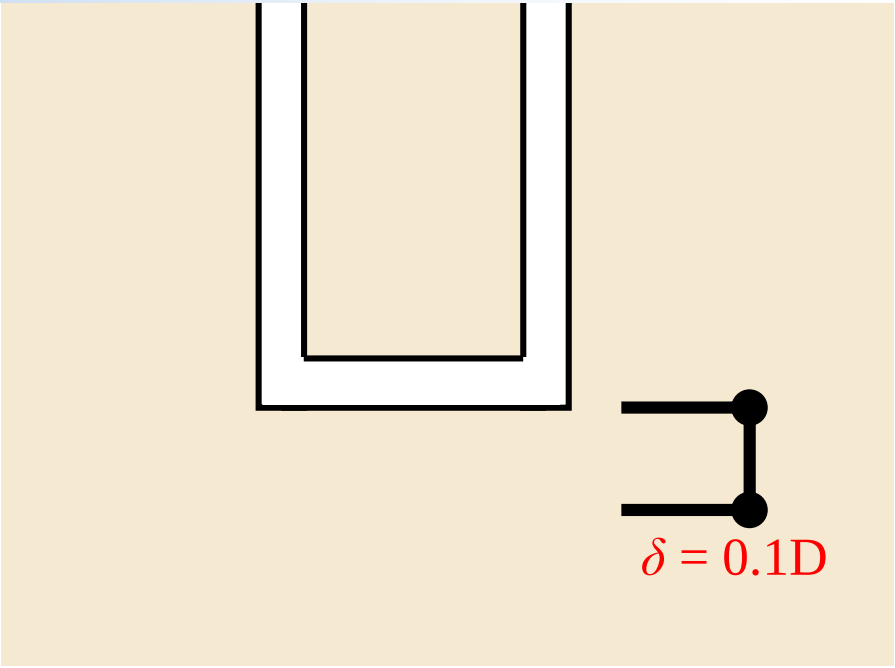
$$R_p = \alpha \cdot \overline{N} \cdot A_p \qquad (1)$$

$\overline{R_p}$: End bearing capacity (kN)

α :Bearing capacity factor (kN/ m^2)

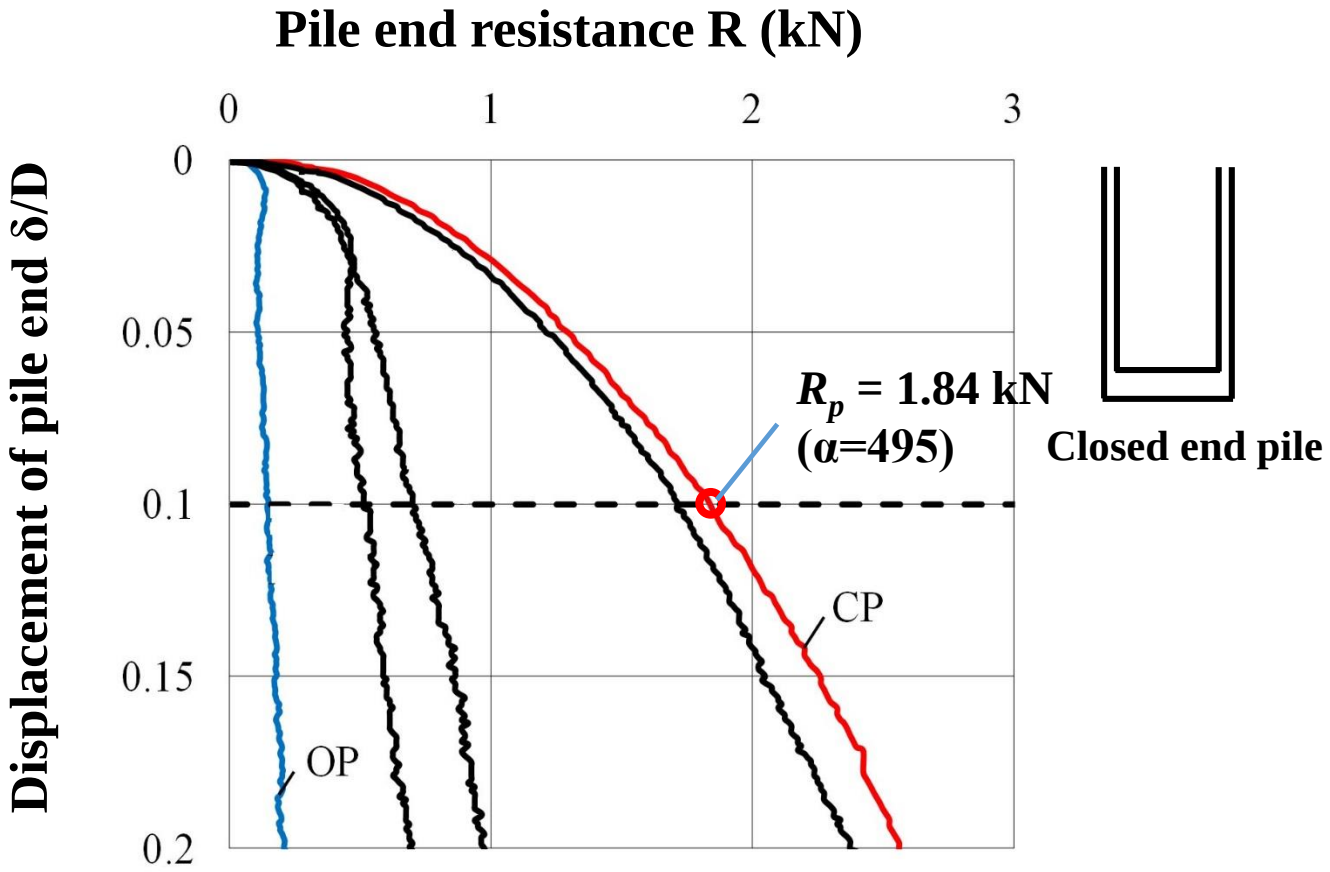
N :Average of N-value of the tip

Ap: Sectional area of the pile tip (m^2)



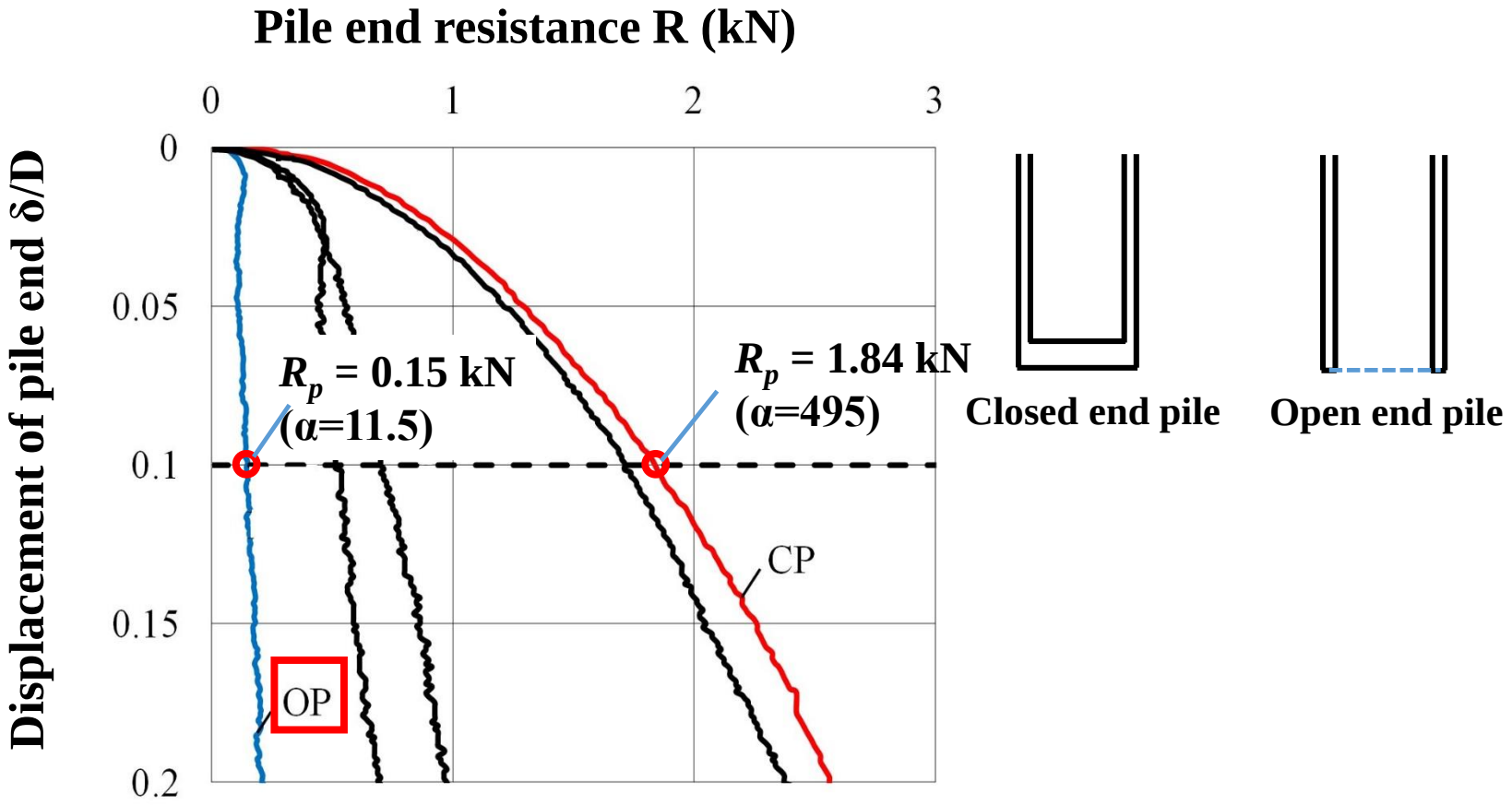
- The end bearing capacity (R_p) of a single pile is calculated by Eq. 1.
- The end bearing capacity (R_p) is given when the pile-end displacement (δ) reaches 10 % of the pile diameter (D).
- The standard value of the bearing capacity factor (α) for the pre bored construction method is α=200.

LABORATORY EXPERIMENT



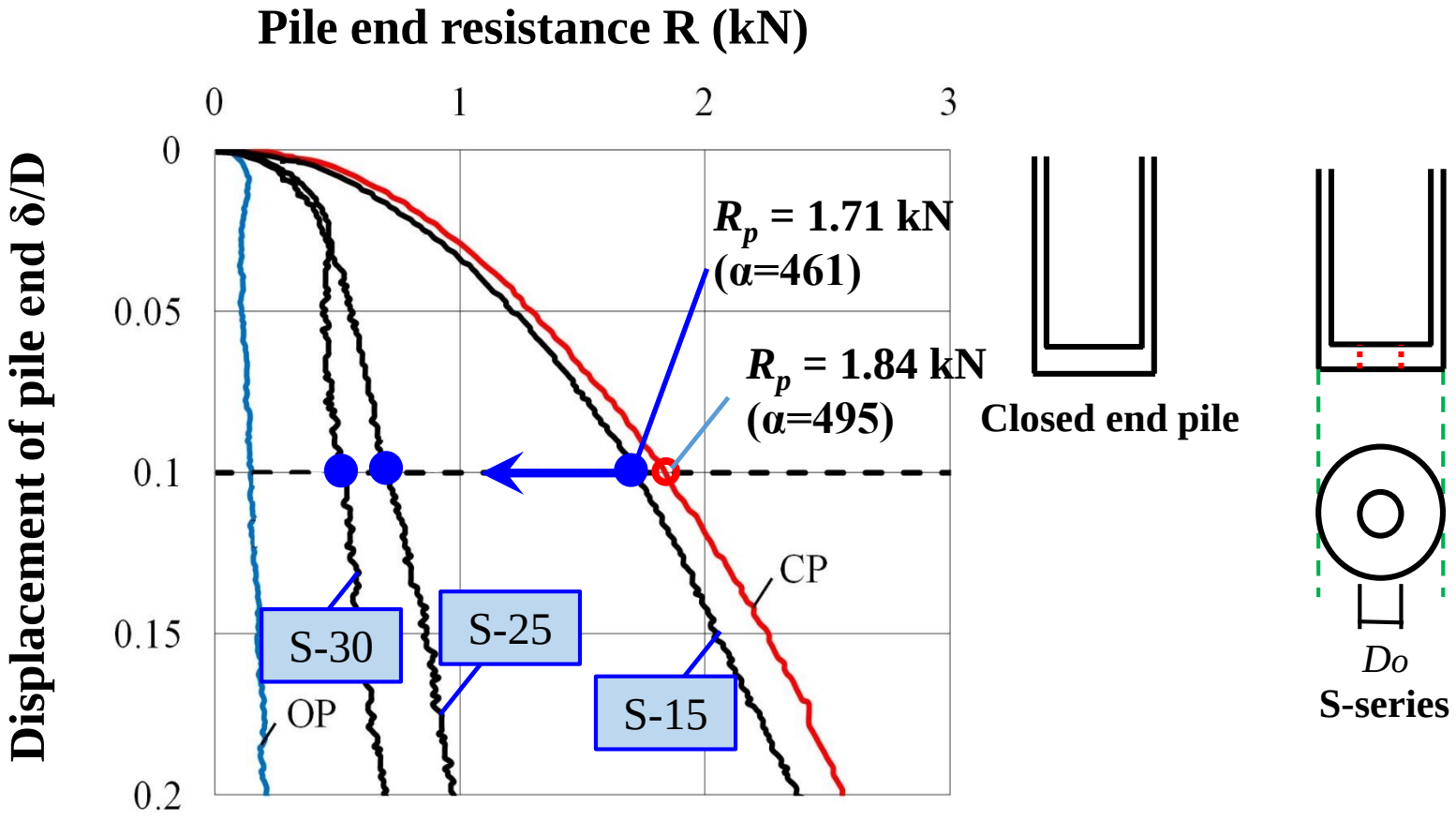
- As for the closed end pile (CP), the pile end resistance(*R*) is increasing from the loading initial stage.
- The end bearing capacity is R_p = 1.84 kN, and the end bearing capacity factor is α = 495. These are sufficient values for end resistance of the prebored construction method.

LABORATORY EXPERIMENT



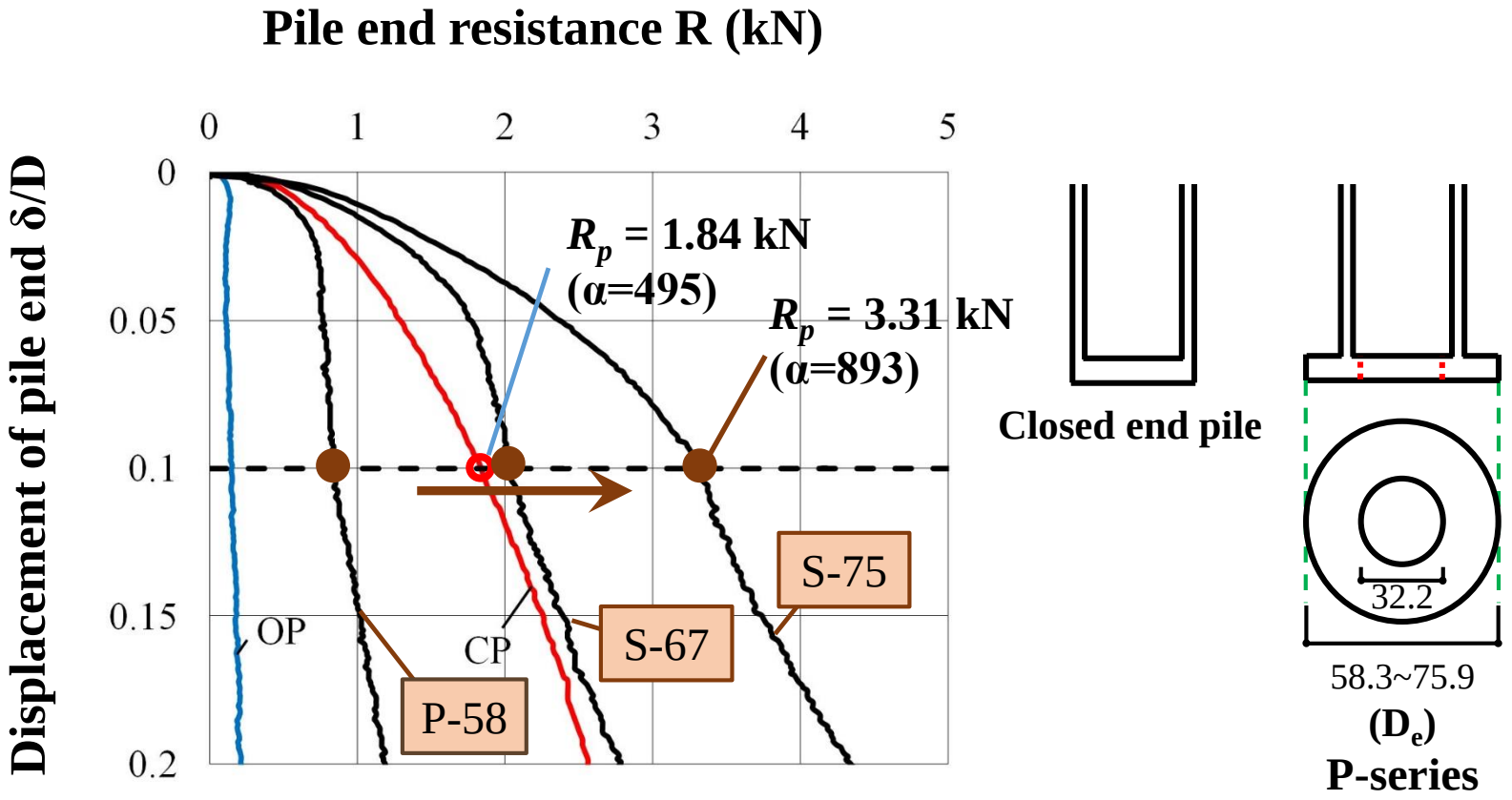
- In the case of the open end pile (OP), the pile end resistance (R) does not large even if the displacement (δ/D) reaches 0.1.
- The end bearing capacity is R_p = 0.15 kN, and the bearing capacity factor is α = 11.5.
- These values are only 8 % of the closed end pile's.

LABORATORY EXPERIMENT



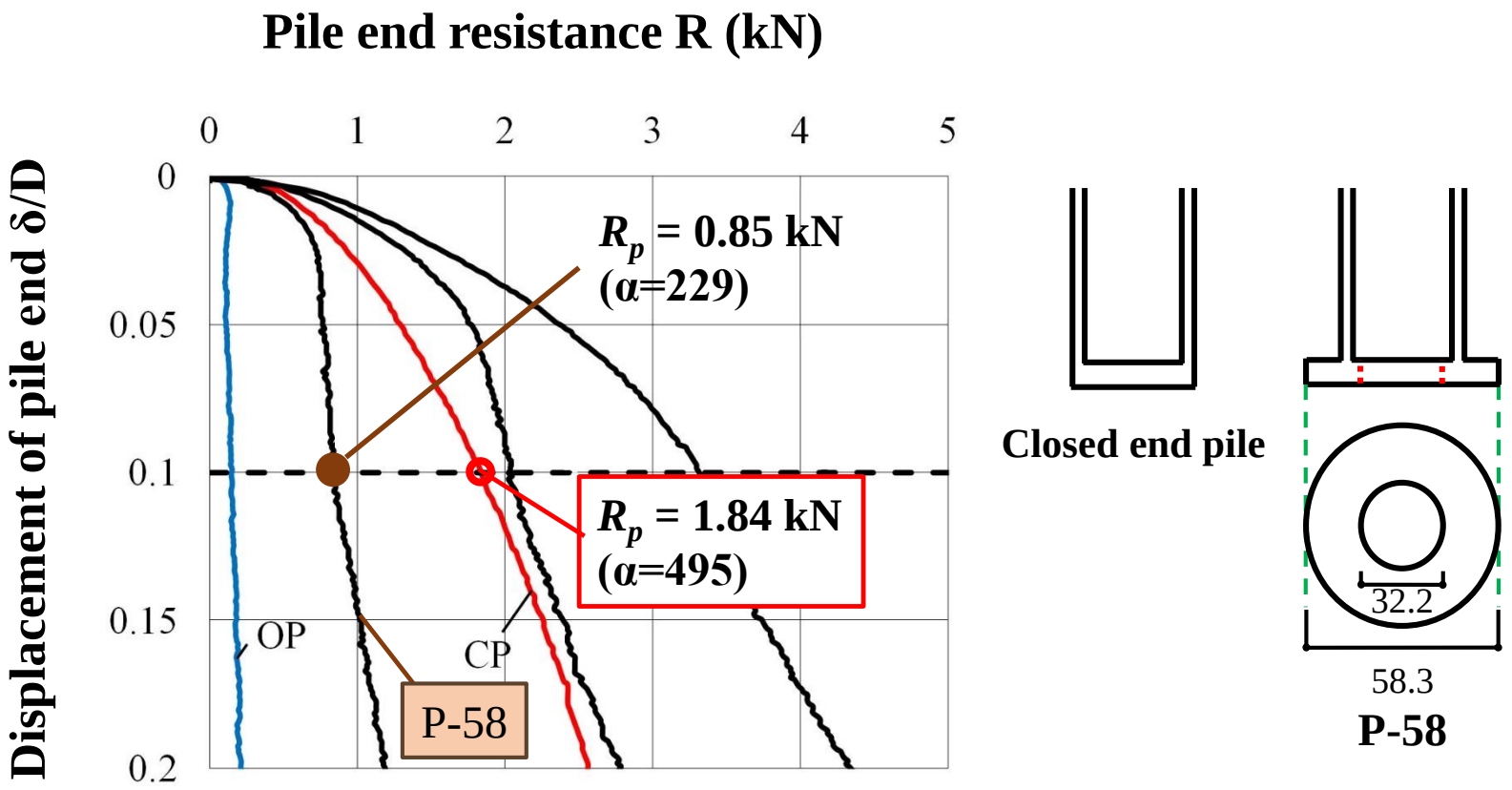
- In the S-series, the larger the opening diameter (D_o) , the smaller the pile end resistance (R).
- The end bearing capacity of S-15 is almost same as CP's. (93% of CP's)

LABORATORY EXPERIMENT



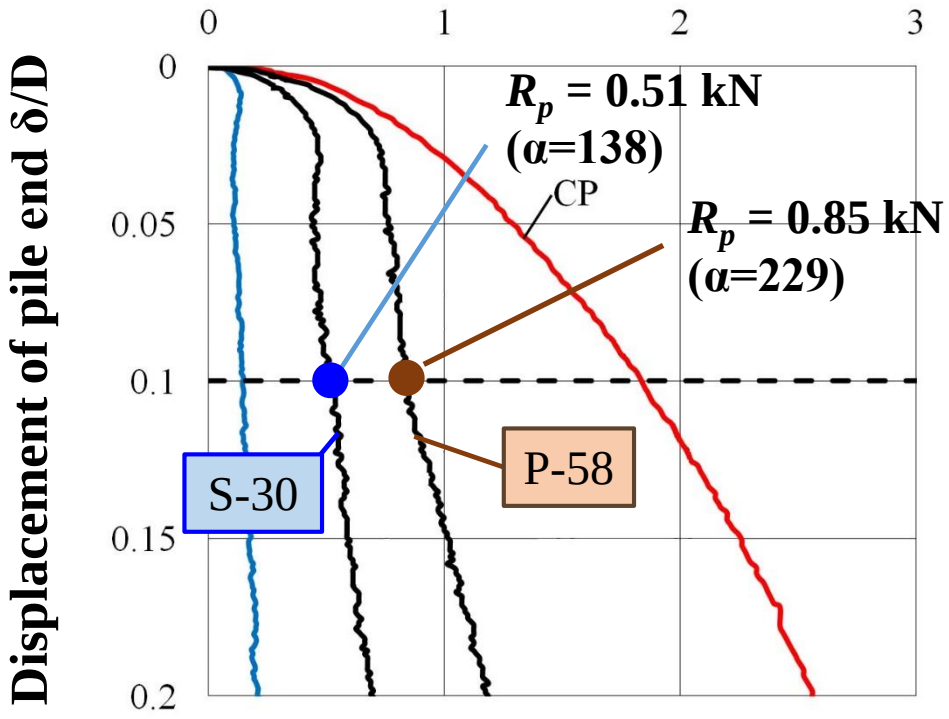
- In the P-series, the larger the external diameter (D_e) , the larger the pile end resistance (R).
- We suppose that this phenomenon is caused by the area of the pile end.
- In case of P-58, the pile tip area is same as CP's.
- The end bearing capacity of P-75 is 1.7 times larger than CP's.

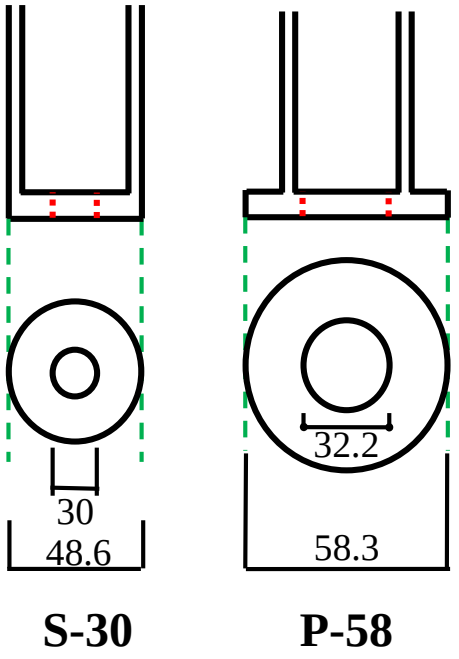
LABORATORY EXPERIMENT



- In case of P-58, the pile tip area is same as CP's.
- But the R_p value of P-58 is only 40% of CP's.
- This phenomenon shows that the end bearing capacity is affected by the opening even if the end area is the same.

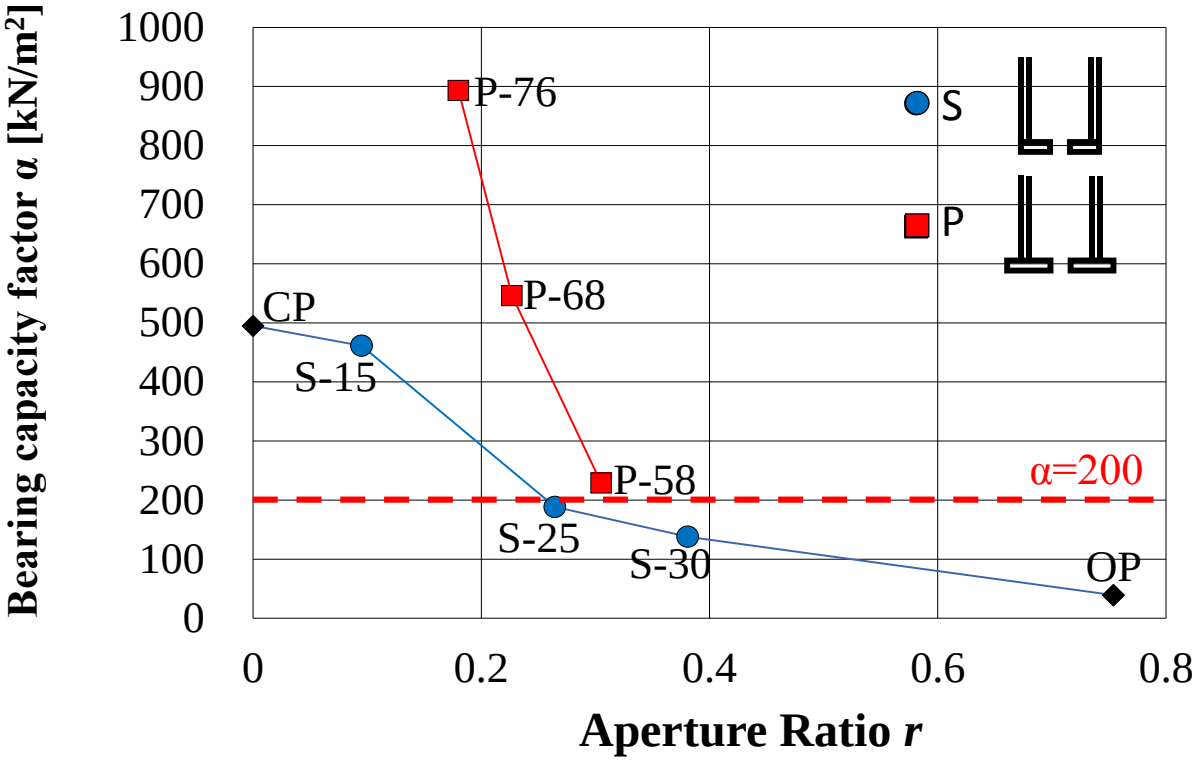
LABORATORY EXPERIMENT





- Furthermore in P-58, the opening area is almost same as S-30's.
- However, the R_p value of P-58 is about 1.6 times larger than S-30.
- This result is signifies that the end disk plate contributes to provide for the large end bearing capacity.

LABORATORY EXPERIMENT



- The aperture ratio *r* is the ratio of the opening area to the whole area of the tip.
- In the S-series, when *r* is larger than 0.27, α-value become smaller than the standard value of the prebored construction method.
- However in the P-series, all test results are larger than S-series, and they are also larger than the standard values.

DESIGN MANNER OF THE END DISK PLATE

- According to the results of the laboratory experiment, the end disk plate is effective for improvement in the end bearing capacity.
- However, the larger disk plate might scrape the soil off a bored hole
- An enough opening is needed to fill the inner space of the pile with the cement milk.
- The dimensions of the plate are designed as follows;

1. The area ratio (r_A) should be more than 1.0 (r_A>1.0).

   $r_A = A/A_0$, A : Whole area of pile end

   A_0 : Sectional area of pile body.

2. The digging diameter ratio (r_D) should be less than 0.8 (r_D<0.8).

   $r_D = D_e/D_D$, D_e : External diameter of end disk plate

   D_D : Digging diameter

3. The opening diameter (D_0) should be more than 80 mm (D_0 >80 mm)

4. The aperture ratio (r) should be less than 0.3 (r<0.3).

   $r = D_o^2/D_e^2$, D_o : Opening diameter of end disk plate

   D_D : Digging diameter

FIELD EXPERIMENT

Test Site

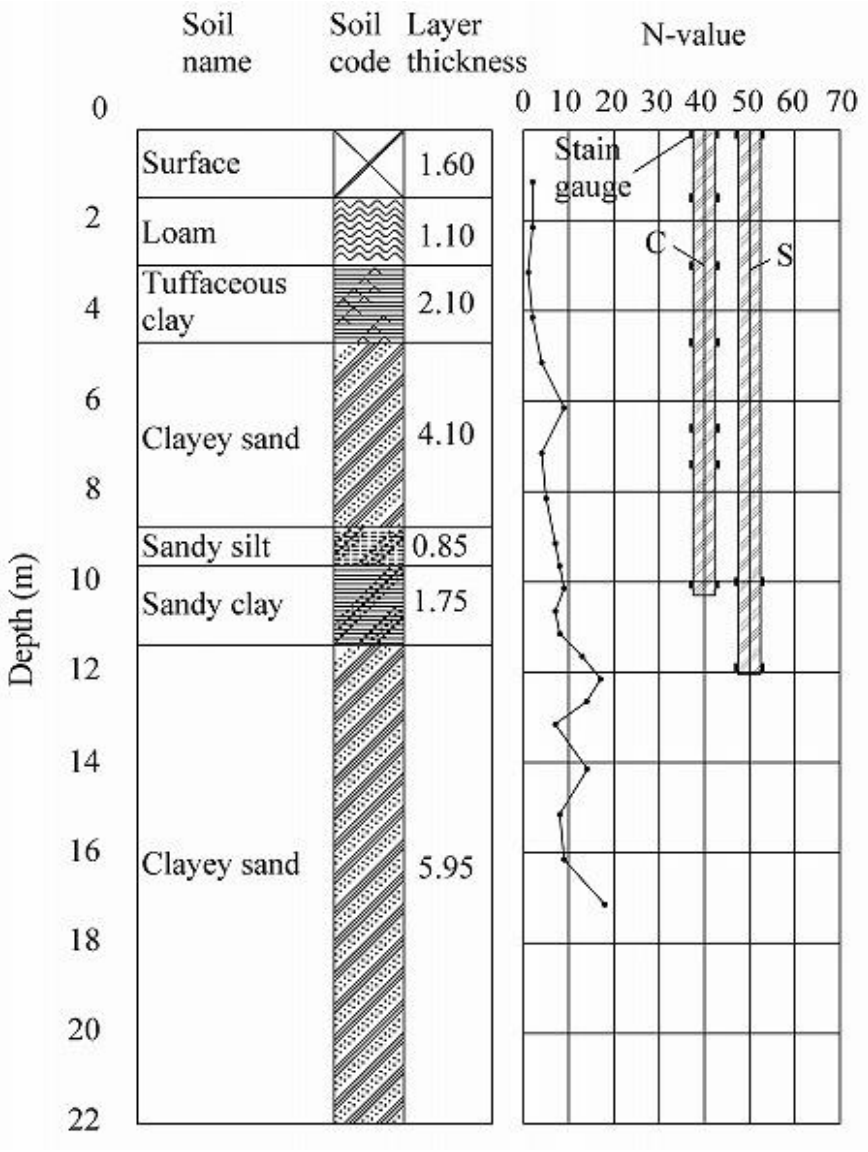
- Two kinds of loading tests were performed in Morokawa-city located in mid area of the Kanto plane.

Test Pile

- We used an general small-diameter steel pipe piles.
  - Diameter is 165.2 mm (D).
  - S-pile : Embedded in Clayey Sand. $\overline{N}$ is 5.8.
  - C-pile: Embedded in Sandy Clay. $\overline{N}$ is 8.8.

End Disk Plate

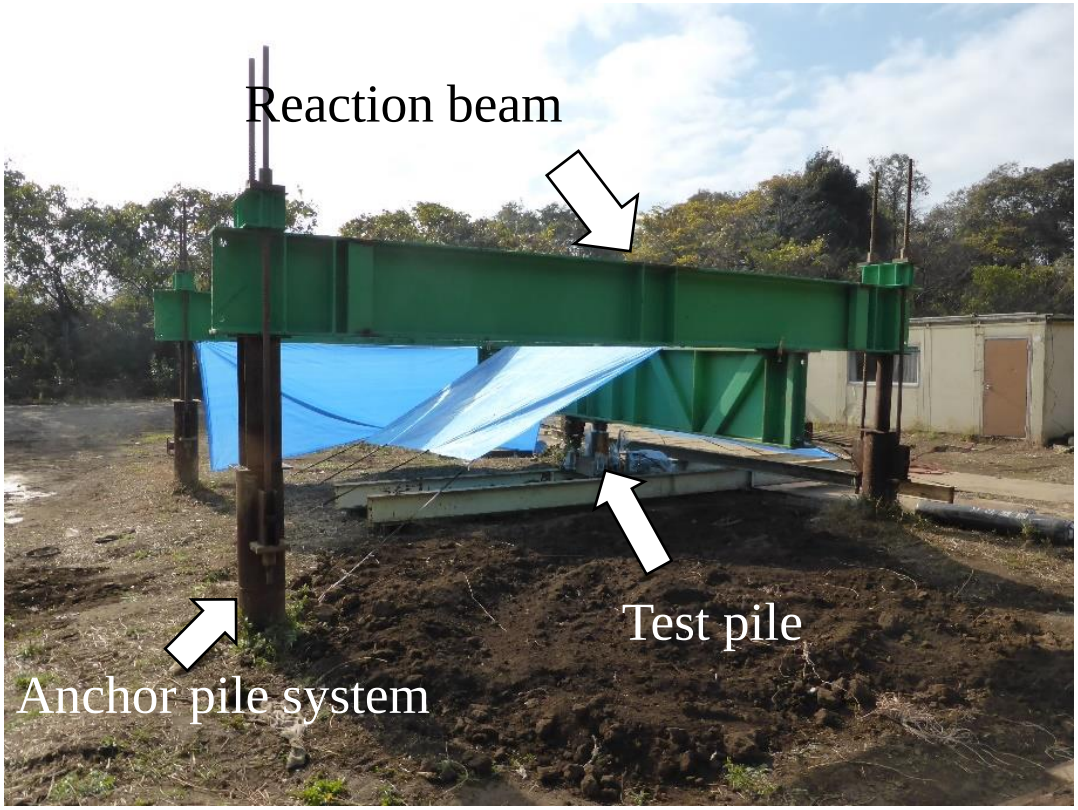
- Holed disk plate were melded on the end.
  - External diameter is 225.2 mm (D_e).
  - Opening diameter is 85.2 mm (D_o).



Boring logs of field test

FIELD EXPERIMENT

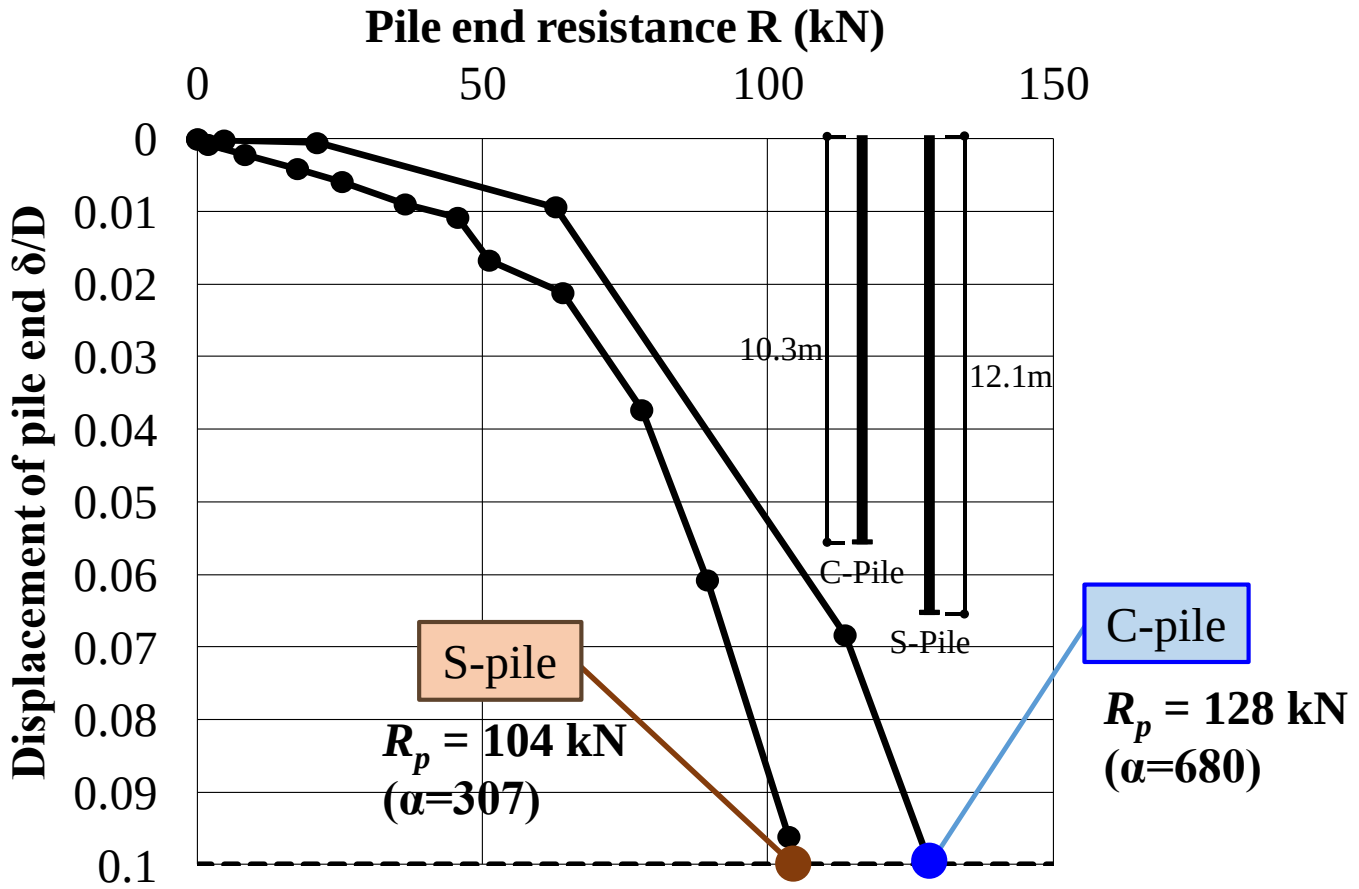
End disk plate on pile end



Loading system of the anchor pile system

- Static axial load tests are executed according to the test manual using the anchor-pile-system (produced by the Japanese Geotechnical Society).
- The strain and displacement of the pile tip are measured.
- The pile end load is converted by values of the strain gauges.

FIELD EXPERIMENT



- S-pile : The end bearing capacity (R_P) indicates 104 kN and the bearing capacity factor (α) is 307.
- C-pile : R_P *is* 128 kN and α-value is 680.
- We can confirm the validity of the disk plate added to the pile tip.

FIELD EXPERIMENT

Digging out investigation

Pile tip situation (S-Pile)

- We could not find any damage and crack.

- Some small lump of soil are exist on the surface, but we could confirm that the pile tip has solidified united with cement milk.

CONCLUSION

- In the cement milk pile construction method, there is some possibility of decreasing the end bearing capacity due to the insufficient stiffness of pile end.
- In this paper, we proposed to attach a holed disk plate to the pile end in order to improve the end bearing capacity of a small sized steel pipe pile.
- We examined the influence of the disk plate and the opening of the pile end by the laboratory experiments.
- We proposed the design manner of dimensions of the disk plate.
- In actual sized field tests, two test results showed large and sufficient end bearing capacities.

Thank you very much for your kind attention