


# Treasure's report of 1<sup>st</sup> Lizzi Scholarship



IWM2006 in Schrobenhausen, Germany: May 5th, 2006

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# Treasure's Report 1st Lizzi Scholarship (IWM2004)

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| <b>Date</b>  | <b>Type of Expense</b>                  | <b>Total</b>                 |
|--------------|---|------------------------------|
| 2004/08/24   | Rail fare from Toyohashi to Tokyo       | 8,190 yen                    |
|              | Rail fare from Shibuya to Kachidoki     | 600 yen                      |
| 2004/08/25   | Rail fare from Kachidoki to Denen-chofu | 410 yen                      |
|              | Rail fare from Denen-chofu to Kachidoki | 410 yen                      |
| 2004/08/26   | Rail fare from Kachidoki to Denen-chofu | 360 yen                      |
|              | Rail fare from Negishi to Kachidoki     | 710 yen                      |
| 2004/08/27   | Lodging charge for three nights         | 19,080 yen                   |
|              | Rail fare from Kachidoki to Denen-chofu | 360 yen                      |
|              | Rail fare from Oyamadai to Oimachi      | 190 yen                      |
|              | Rail fare from Tokyo to Toyohashi       | 8,190 yen                    |
| <b>TOTAL</b> |   | <b>38,500 YEN (\$351.41)</b> |

Simulation of the Confining Effect on  
Bearing Capacity of Micropile Foundation;  
-- Field Loading Test and FEM Simulation --



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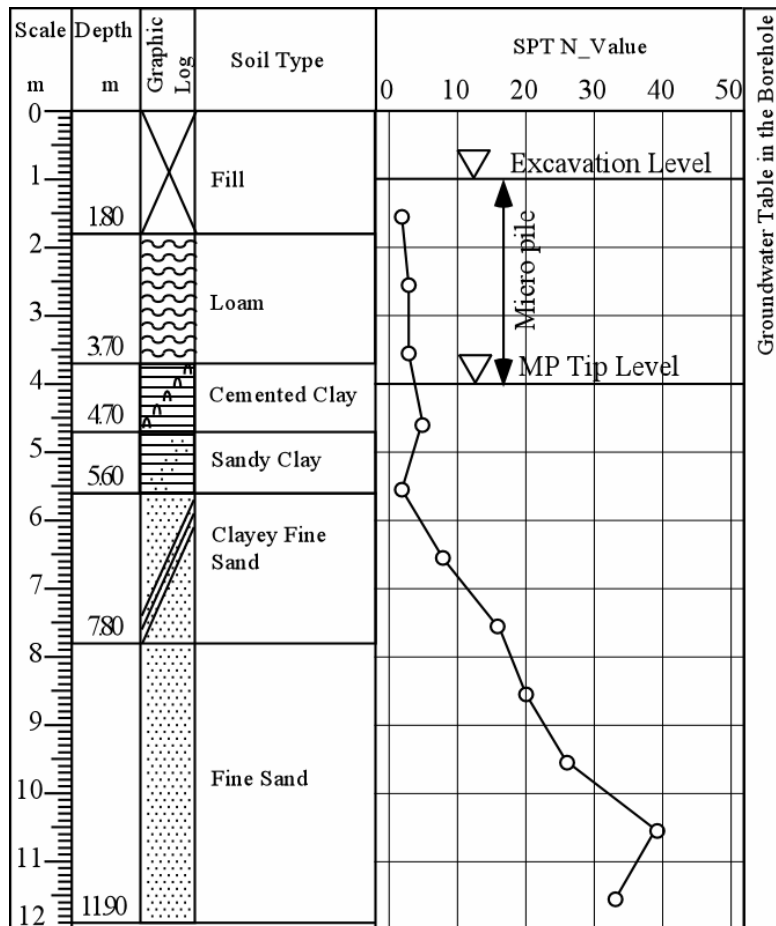
- Purpose
- Field Loading Test
  - Prestressed micropile method
- FEM simulation
  - Confining effect
  - Effects of network and prestress
- Summary and future plan

# The purpose of this study

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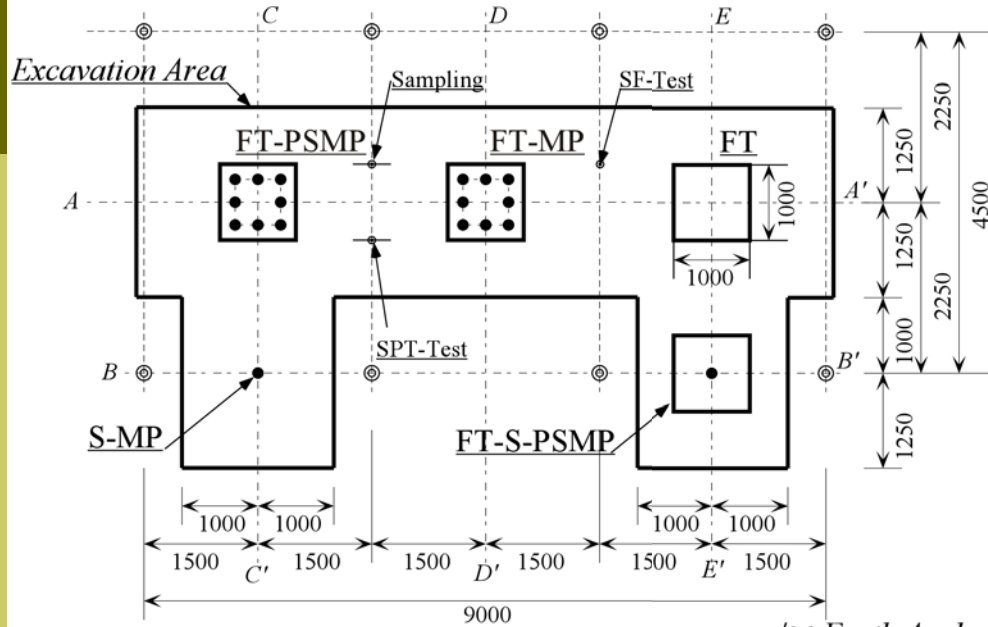
- Early studies (Otani, Tsukada, Miura et al)
  - “Model Loading Tests on The Footing Reinforced with Prestressed Micropiles”
  - “Large-Scaled Field Loading Test on The Footing Reinforced with Prestressed Micropiles”
  
- Analytic clarification of the mechanism of the mobilization of load bearing capacity of foundation reinforced with prestressed micropiles

# Field loading test



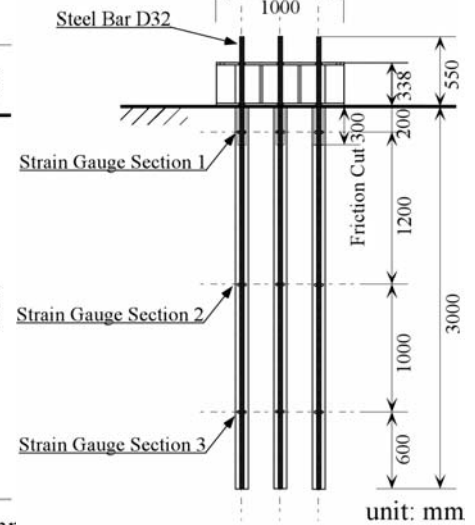
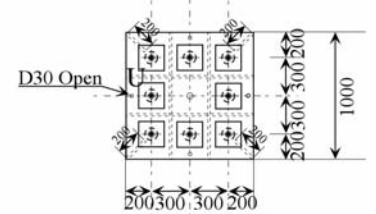
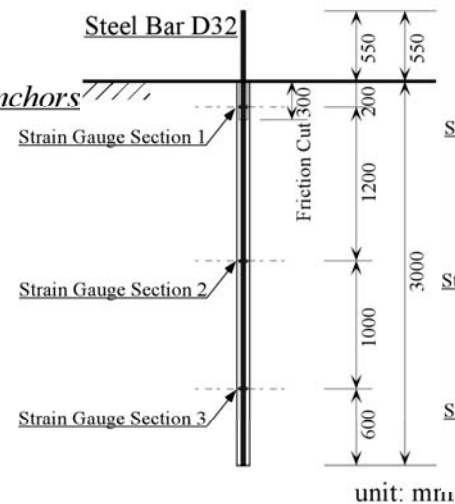
- The boring log and the SPT N-value of the upper 10 meters
- The subsoils are fill, loam, cemented clay, sandy clay, and fine sand, respectively.
- The fill, loam and clay are soft; the SPT N-values are less than 5.

# Field loading test



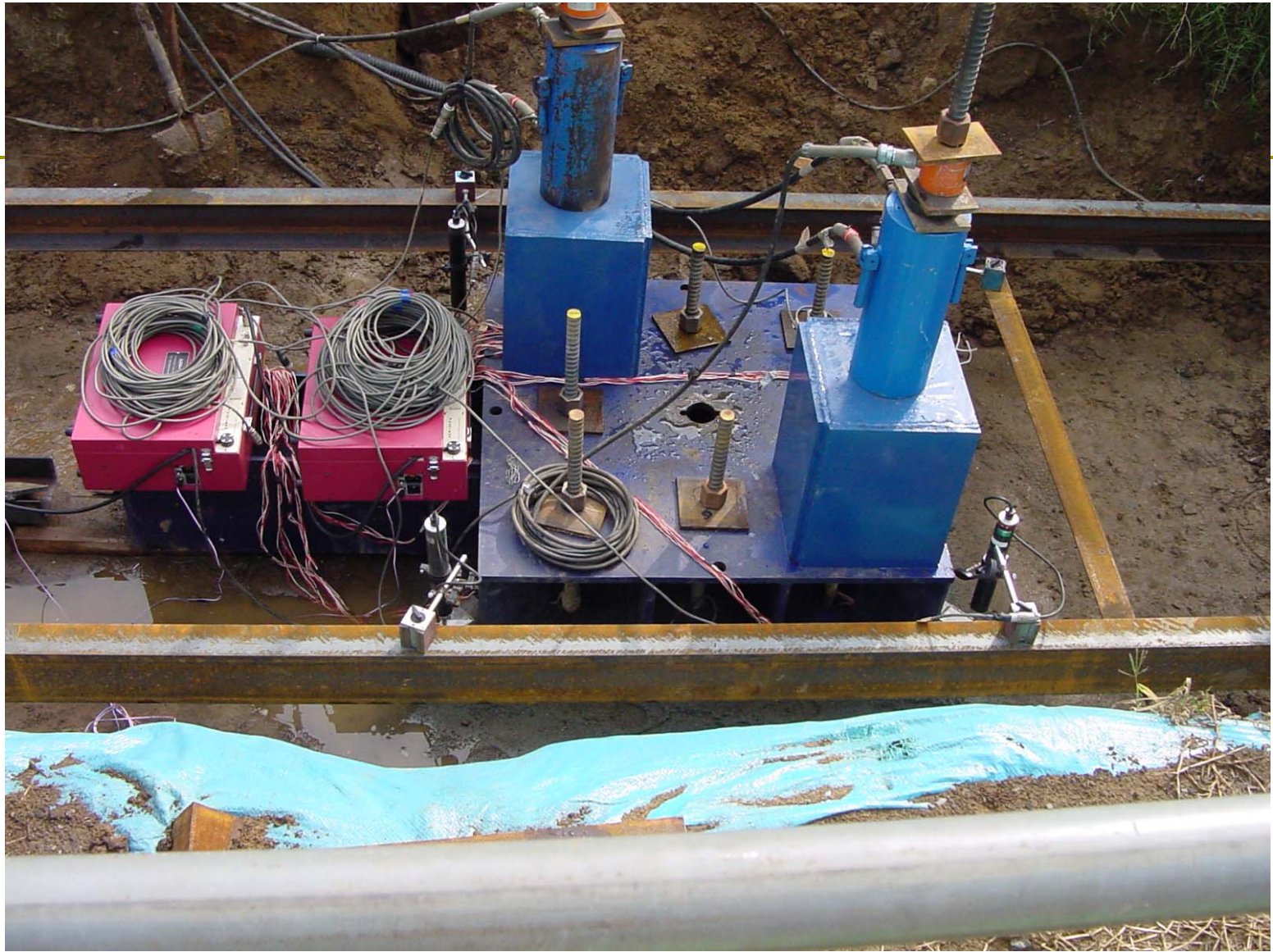
The micropile is 3 m long, 100 mm in diameter, with a steel bar of 32 mm in diameter

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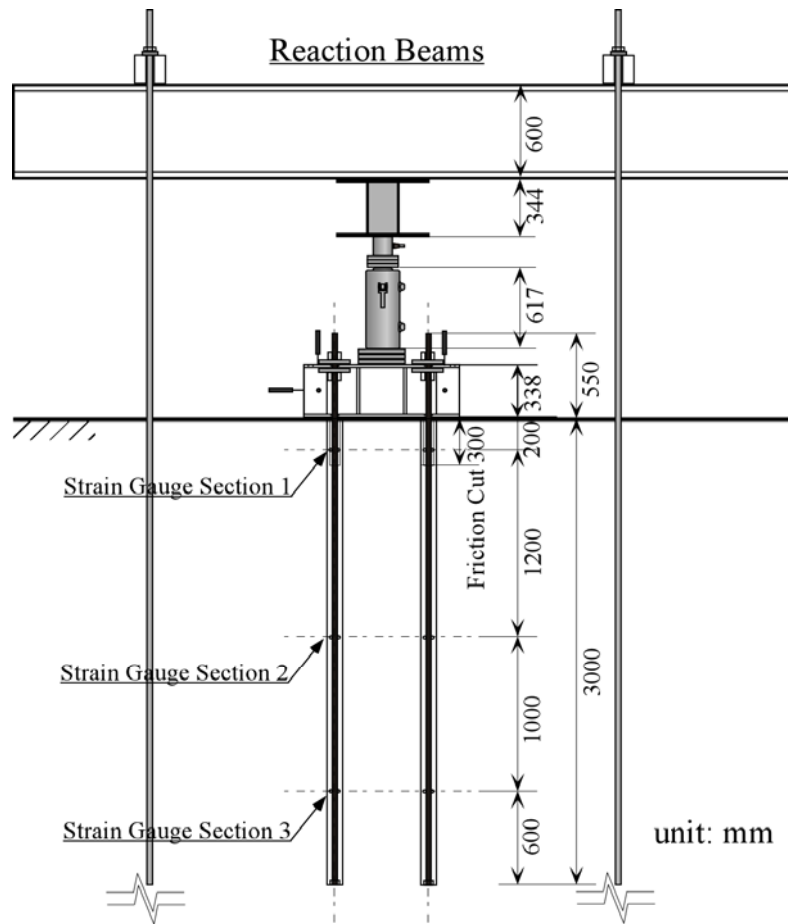
(a) S-MP

(b) FT-MP/FT-PSMP

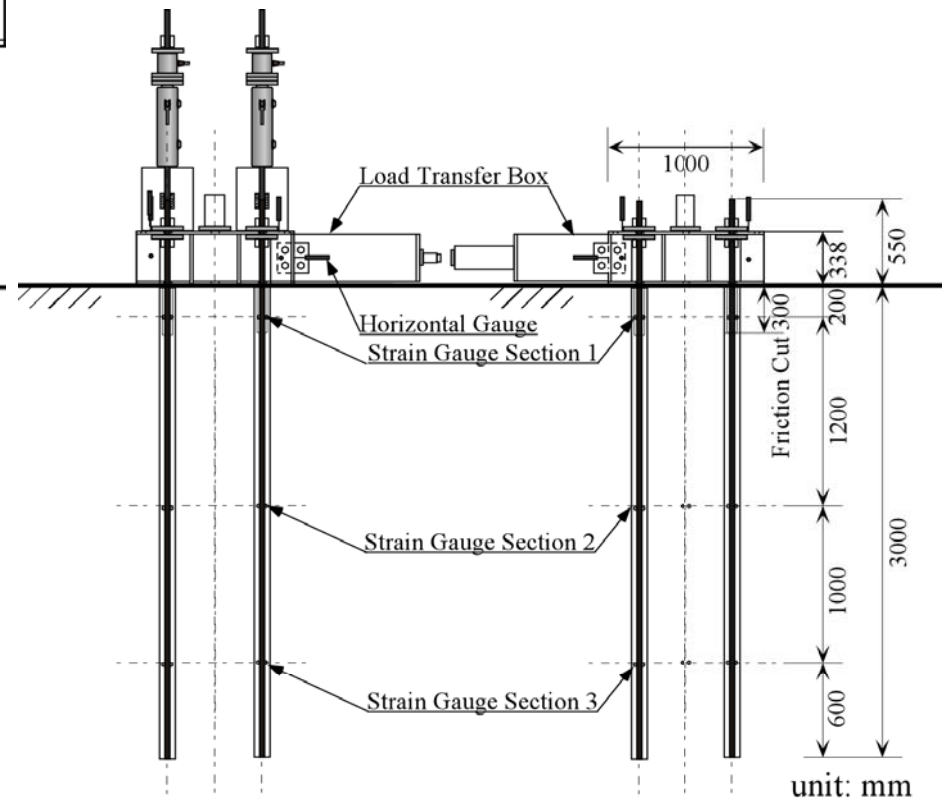




# Loading apparatus



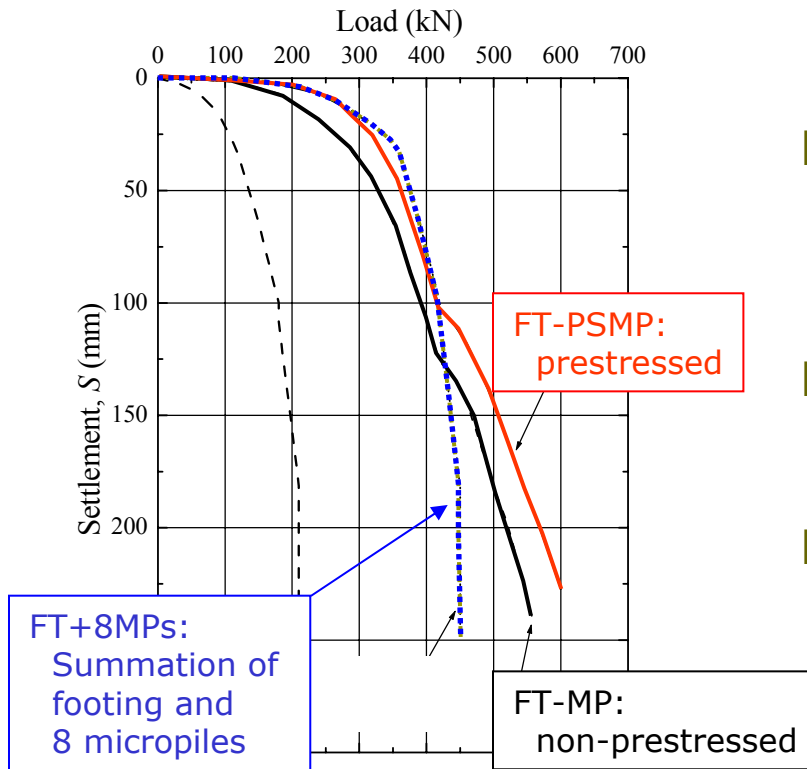
Vertical Loading test



Horizontal Loading test



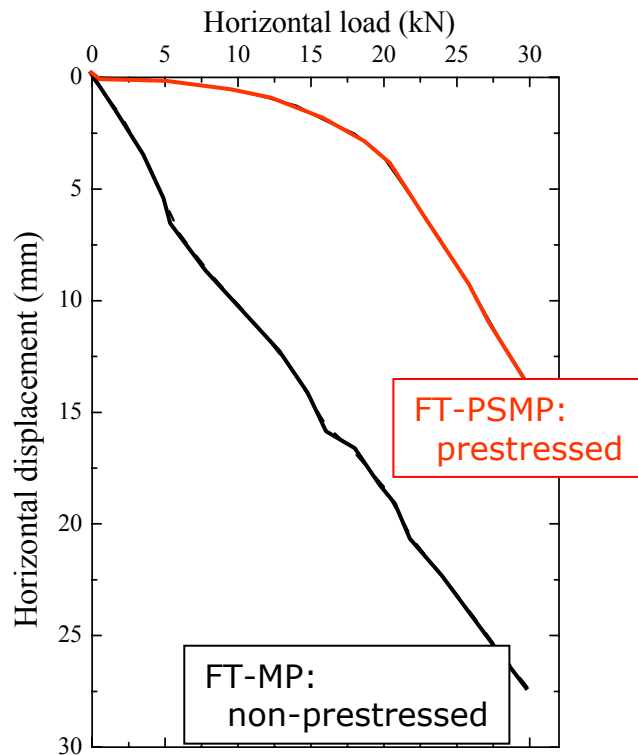
# The results of vertical loading tests



- Initial coefficient of subgrade reaction
- FT-MP(non-prestressed)
  - $1.86 \times 10^4 \text{ kN/m}^3$
- FT-PSMP(prestressed)
  - $3.97 \times 10^4 \text{ kN/m}^3$

Also in field loading test, network effect was mobilized. The settlement became half due to the effect of prestress.

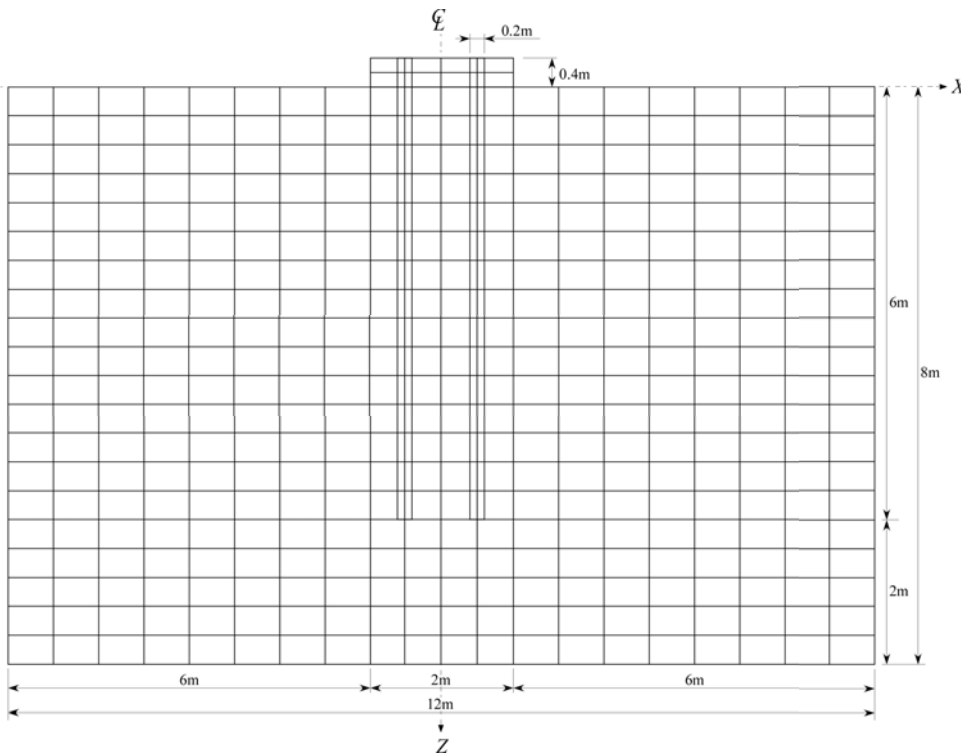
# The results of horizontal loading tests



- Initial coefficient of subgrade reaction
- FT-MP(non-prestressed)
  - $1.01 \times 10^3 \text{kN/m}^3$
- FT-PSMP(prestressed)
  - $17.1 \times 10^3 \text{kN/m}^3$

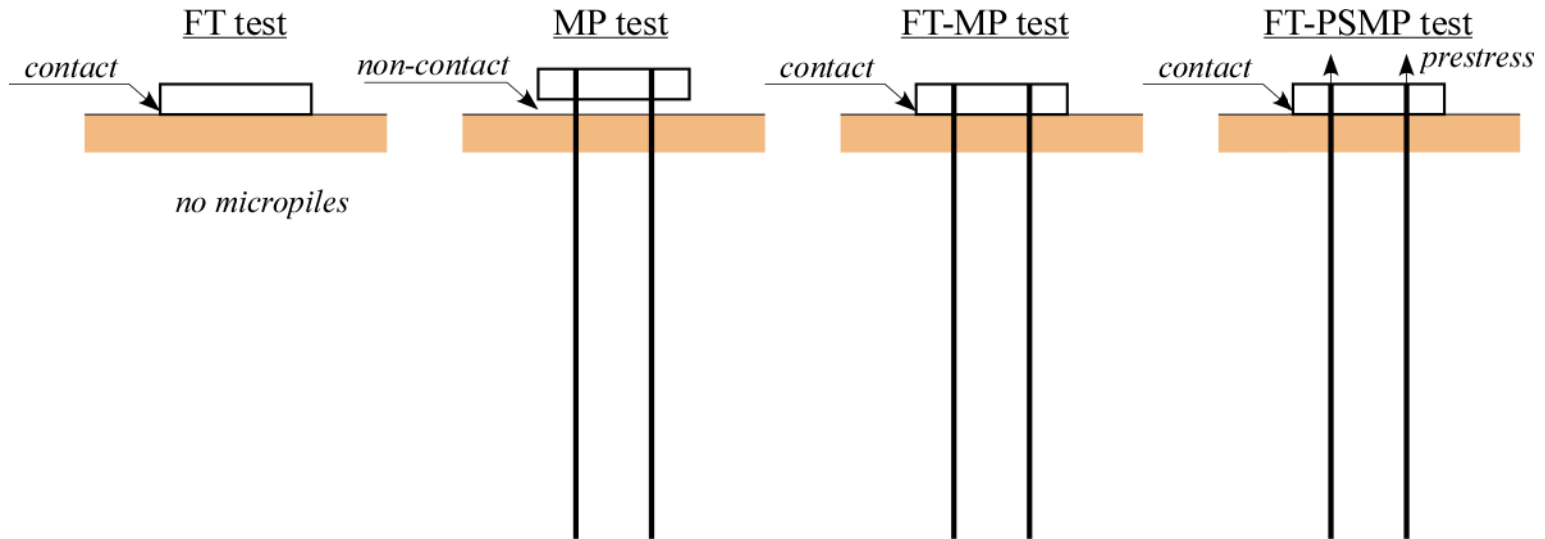
The effect of prestress was significant in the horizontal movement control.

# FEM simulation

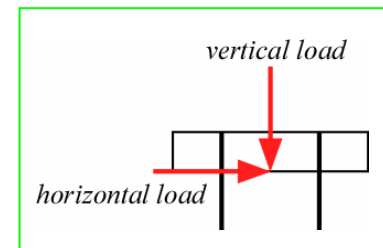


- Footing:
  - rigid material
- Micropiles:
  - elastic bending material
  - second-order FEM elements
- Ground:
  - elasto-plastic model
  - Drucker-Prager Type
- Ground - Micropiles:
  - bi-linear slider element

# Analysis condition



- Type of foundation
  - Footing, Micropile(MP), MP-footing, and prestressed MP-footing
- Ground
  - Dense sand and Loose sand
- Loading
  - Vertical and Horizontal Loading



# Input parameters

## Dilatancy angle

$\psi > 0$  : positive dilatancy

$\psi < 0$  : negative dilatancy

### □ Mechanical properties

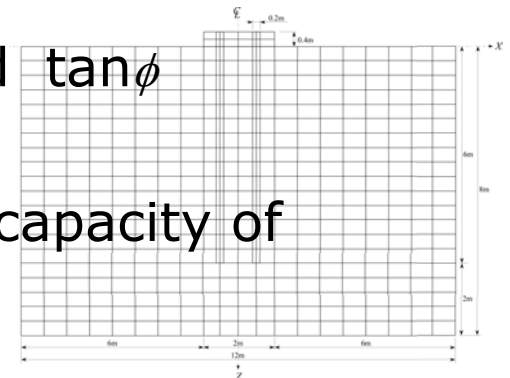
|            | $\phi$ (°) | $c$ (N/m <sup>2</sup> ) | $\psi$ (°) | $\rho$ (kg/m <sup>3</sup> ) | $E$ (N/m <sup>2</sup> ) | $G$ (N/m <sup>2</sup> ) | $\nu$ |
|------------|------------|-------------------------|------------|-----------------------------|-------------------------|-------------------------|-------|
| Dense sand | 35         | 0                       | 10         | $2.00 \times 10^3$          | $1.04 \times 10^8$      | $1.20 \times 10^8$      | 0.3   |
| Loose sand | 30         | 0                       | -10        | $1.90 \times 10^3$          | $0.35 \times 10^8$      | $0.40 \times 10^8$      | 0.3   |
| Micropile  |            |                         |            | $2.40 \times 10^3$          | $70 \times 10^8$        | $2.69 \times 10^9$      | 0.3   |

### □ Friction angle between Ground and Micropiles

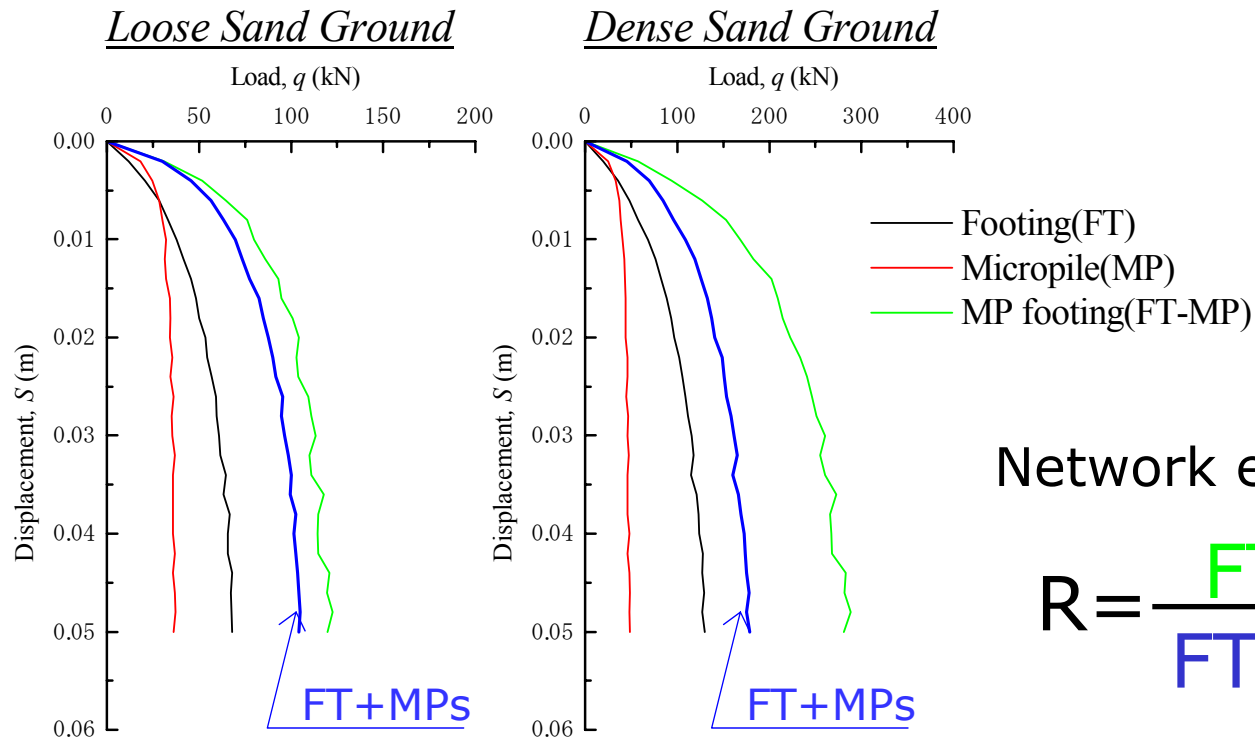
- Internal friction angle of ground  $\tan \phi$


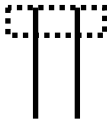
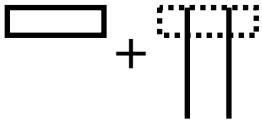
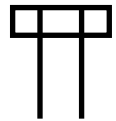
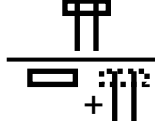
### □ Prestress

- Approximately 30% of bearing capacity of micropiles



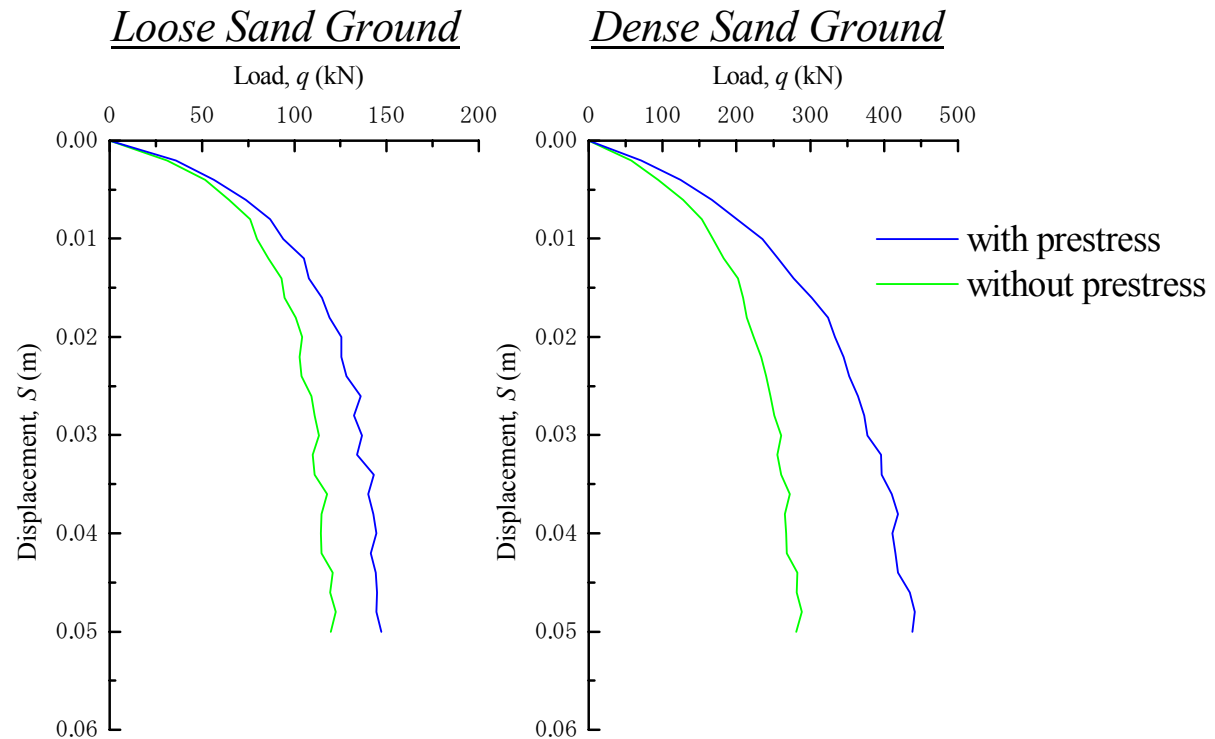
# Vertical Loading Condition (Confining Effect)



| Critical load bearing capacity | FT<br> | MP<br> | FT+MPs<br> | FT-MP<br> | R<br> |
|--------------------------------|---|--|---|--|--|
| Dense sand                     | 124   | 45   | 169   | 307  | 1.82   |
| Loose sand                     | 64  | 35   | 99  | 123  | 1.24   |



# Vertical Loading Condition (Effect of prestress)



## Loose sand

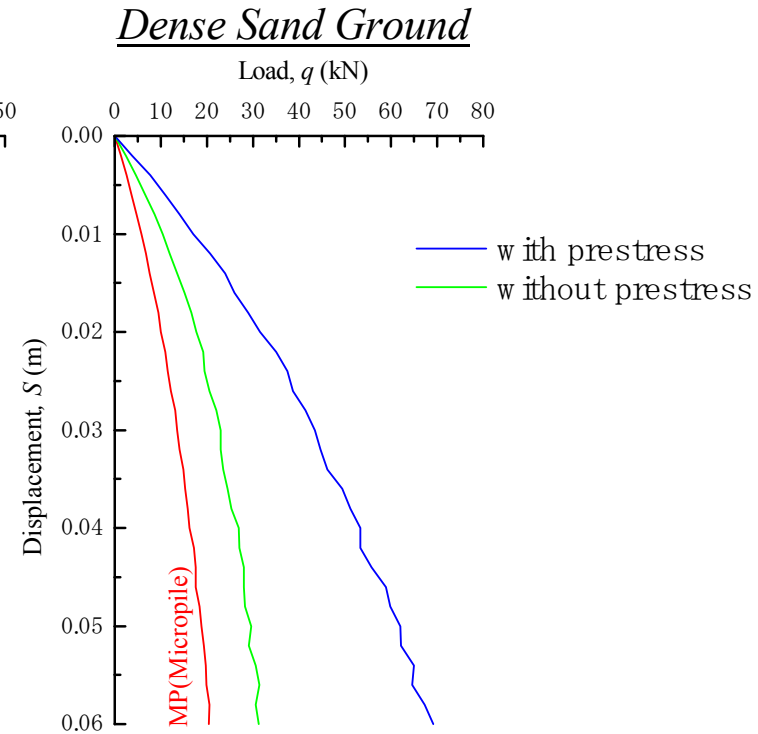
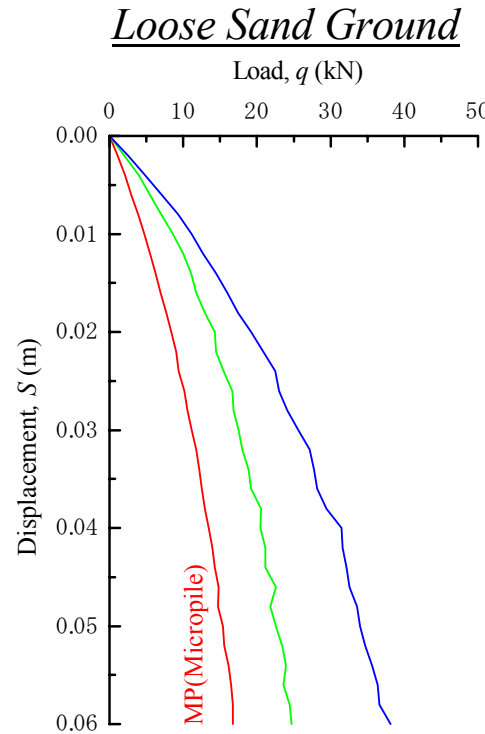
## Dense sand

|  | FTMP  | FT-PSMP |
|--|-------|---------|
| Critical bearing capacity                | 123   | 156     |
| Initial Coefficient of subgrade reaction | 19000 | 20000   |

|  | FTMP  | FT-PSMP |
|--|-------|---------|
| Critical bearing capacity                | 307   | 436     |
| Initial Coefficient of subgrade reaction | 31000 | 31000   |

# Horizontal Loading Condition

(Effect of prestress)



## Loose sand

## Dense sand

|  | FTMP | FT-PSMP |
|--|------|---------|
| Critical bearing capacity                | 23   | 38      |
| Initial Coefficient of subgrade reaction | 630  | 650     |

|  | FTMP | FT-PSMP |
|--|------|---------|
| Critical bearing capacity                | 31   | 67      |
| Initial Coefficient of subgrade reaction | 760  | 820     |

# Summary and future plan

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- The confining effects on the ground by the micropiles were clearly observed both in the loading tests and FEM simulations
- The effect of the prestress which induced the confinement on the subsoil by the footing and the micropiles, was recognized not only in the loading tests but also in the FEM simulations.

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- The FEM simulation must be modified
    - The yielding of micropiles under the horizontal loading on piles
    - The increase in shear modulus of ground due to the confinement
  - 3-D FEM simulation
    - network of micropiles
    - confining effect

Thank you for your attention !



End of the Presentation