

Micropile for Applying to Artificial - Ground above Railway Site

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Research background

- Artificial ground
 - Definition: reinforced concrete deck above the unused site
 - Purpose: utilization of unused site for residential area
 - Advantage: **creating more space** for the construction site



[Concept of residential area on the artific ground]

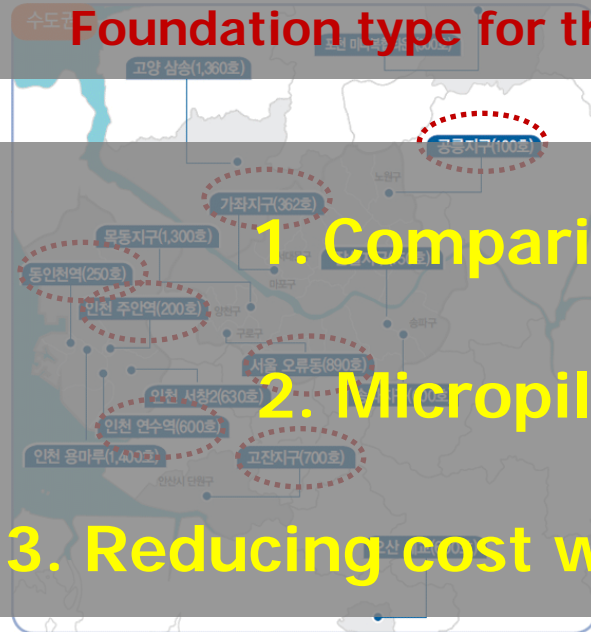


[Real cases of residential area of Hong Kong, Japan and Korea]

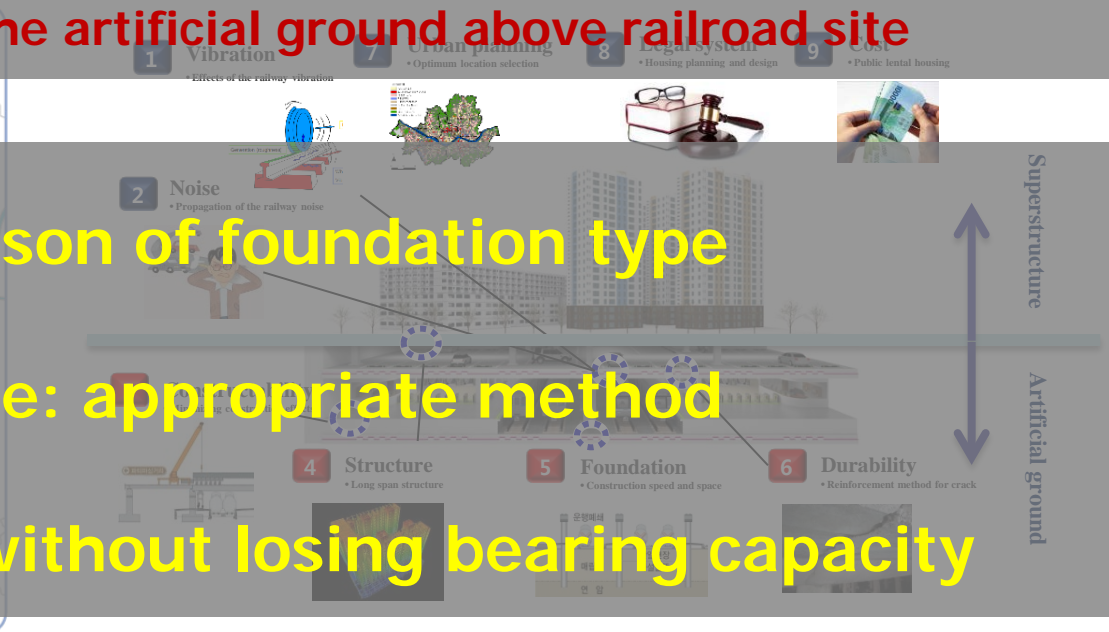
Research background

- Housing project in Korea
 - “Happy house” project on the artificial ground by Korean government
 - 7 Railroad sites out of 15 target sites
 - Technical needs for the foundation type: **space/speed for the construction**

Foundation type for the artificial ground above railroad site



[Site map for the housing project, Korea]



[Technical needs for the construction of the space on the artificial ground]

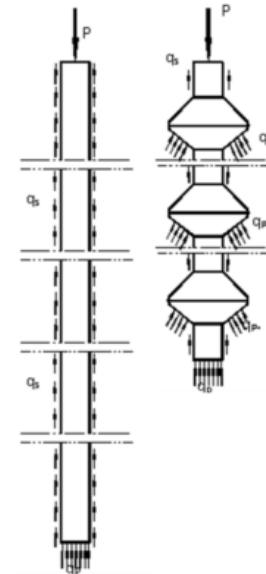
1. Comparison of foundation type

2. Micropile: appropriate method

3. Reducing cost without losing bearing capacity

Development

- New concept of micropile
 - EBP(Extended Branches and Plates) pile system
 - : root shaping on the cast-in-place concrete pile
 - bearing capacity \uparrow , 30-50% of construction speed \uparrow , 30-60% of quantity \downarrow
 - : concept of EBP pile system + improvement of soil



[Concept of EBP pile system]

Development

- Concept of waveform micropile

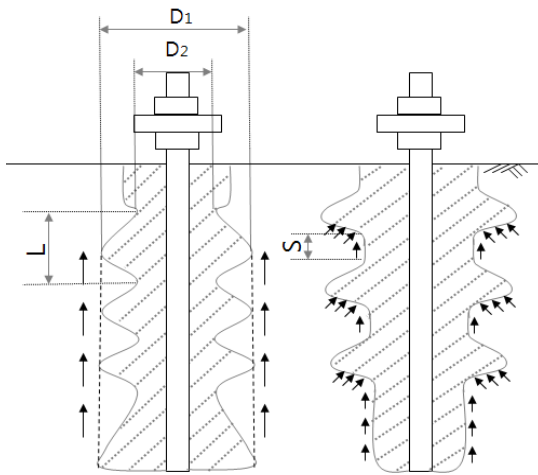
- Waveform micropile

- : shear key shaping of the grout body with soil jet grouting method

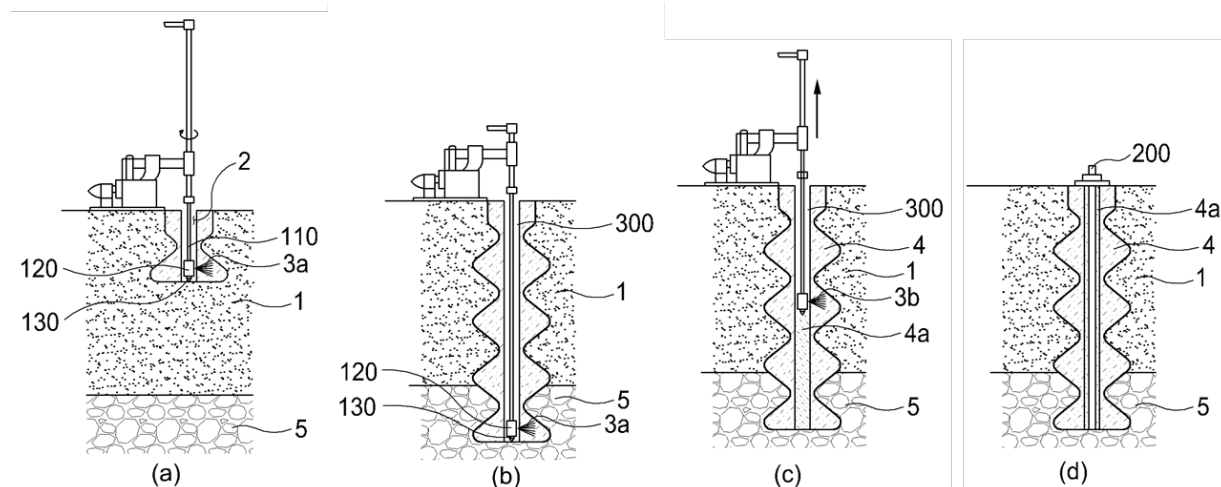
- Main factor: **length** of shear key & **spacing** between shear key

- e.g) $S=0$ → skin friction(o), side friction(x)

- $S>0$ → skin friction(o), side friction(o)



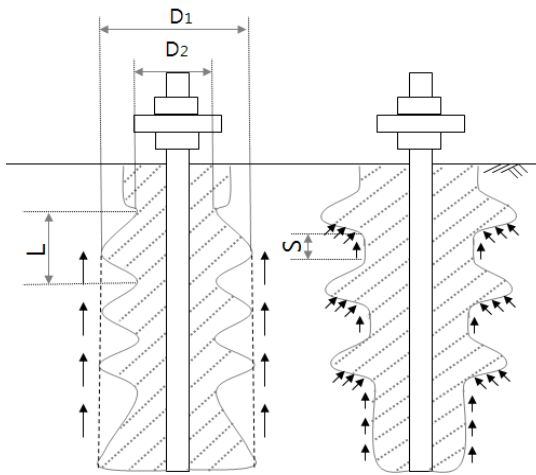
[Waveform micropile]



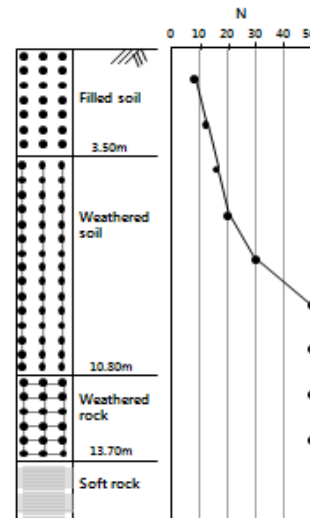
[Sequence of waveform micropile method]

Development

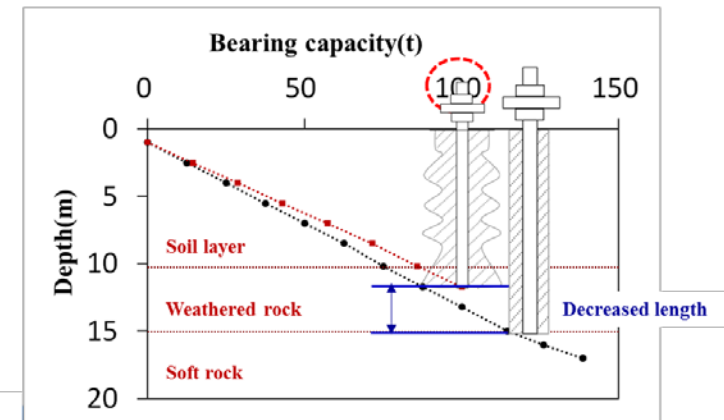
- Concept of waveform micropile
 - Waveform micropile
 - : shear key shaping of the grout body with soil jet grouting method
 - Main factor: **length** of shear key & **spacing** between shear key
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[Waveform micropile]



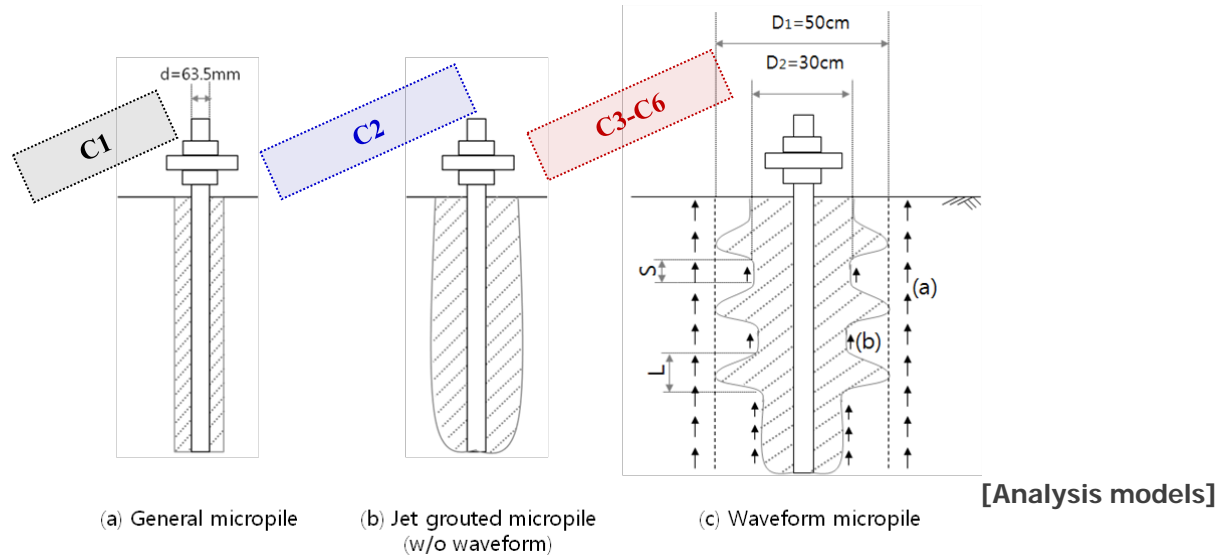
[Boring log of study site]



[Prediction of the cost for the micropile]

Numerical Analysis

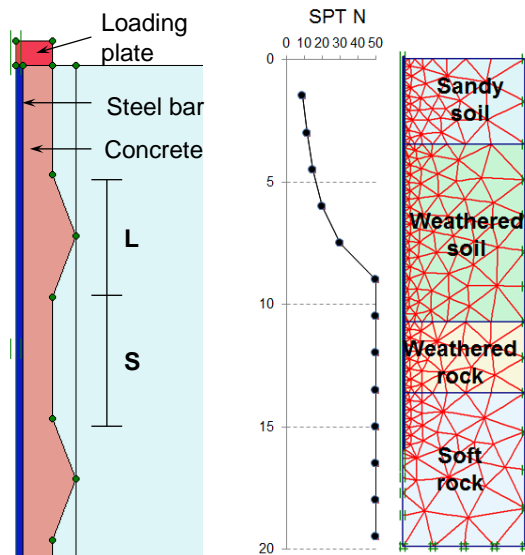
- 3 types of analysis model with different shape



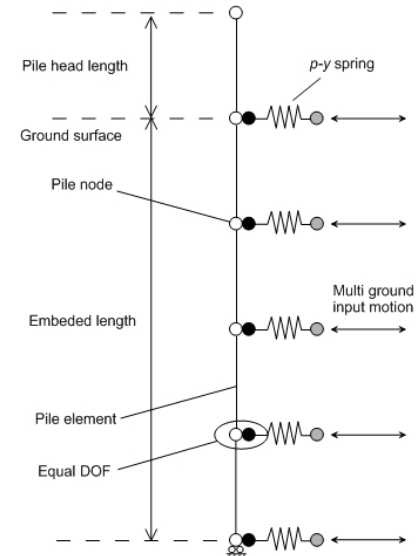
Analysis type			
C1	General micropile D=180mm($f_{ck}^* = 30\text{MPa}$), Length=16m	C2	Micropile with soil jet grouting $D_1 = D_2 = 300\text{mm}$, Length=13.7m
Waveform micropile $D_1 = 500, D_2 = 300\text{mm}$, Length=13.7m			
C3	L:0.5m, S:0.5m	C4	L:0.5m, S:2.5m
C5	L:1m, S:0	C6	L:1m, S:1m

Numerical Analysis

- **Vertical bearing capacity with Plaxis v8.0**
 - triangular elements with fifteen nodes for the soil and pile modeling
- **Lateral bearing capacity with OpenSees**
 - API(1987) p-y curve to describe the pile-soil interaction

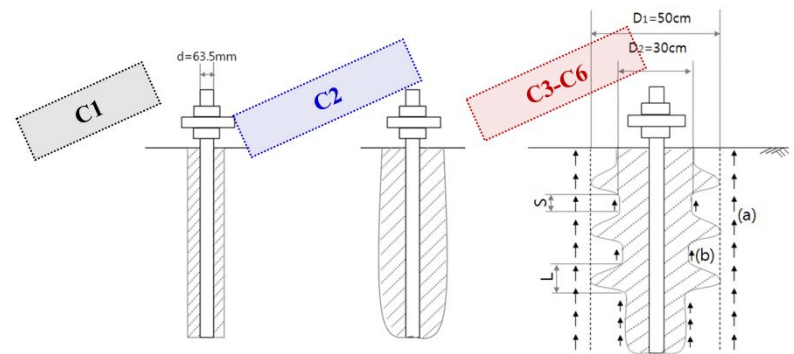
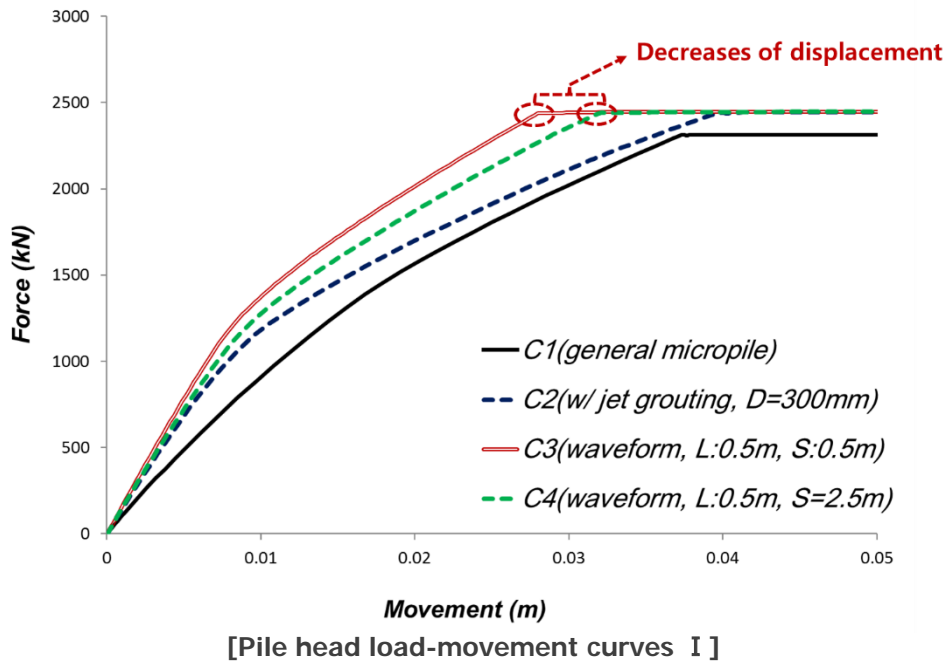


[Soil-pile modelling]



Analysis results

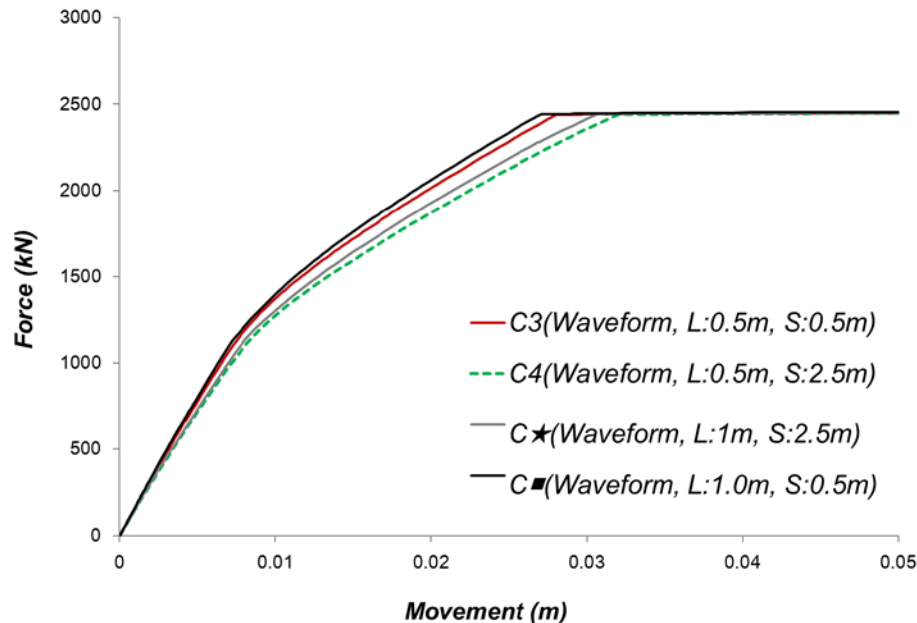
- Vertical bearing capacity
 - Ultimate load: C2(3,720kN), C3 & C4(2,450kN) and C1(2,310kN)
 - Displacement of C3(40%) < C1 → higher bearing capacity
 - Displacement of C3 < displacement of C4



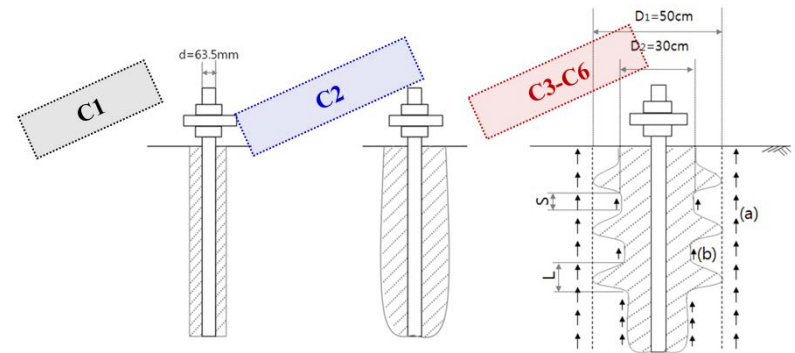
Analysis results

- Vertical bearing capacity

- Comparison of analysis result with the waveform micropiles
- Ultimate load: same values due to same material yield strength
- **Displacement** ↓, number and length of shear key ↑

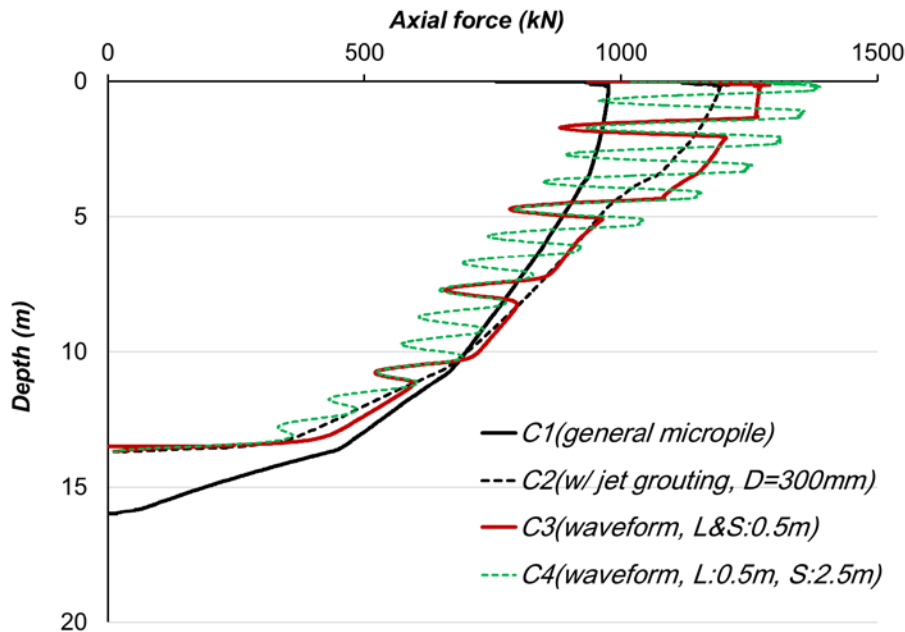


[Pile head load-movement curves II]

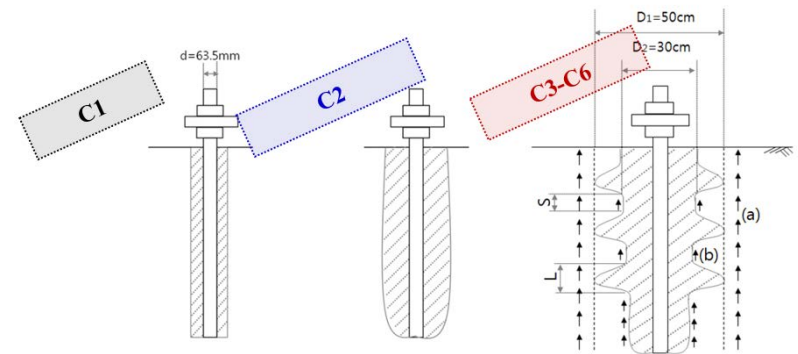


Analysis results

- Vertical bearing capacity
 - Load transfer curve: general micropile vs. waveform micropile($\delta=10\text{mm}$)
 - Waveform micropile: skin friction increases \rightarrow soil depth of 0-3.5m
(better achievement of skin friction at relatively soft soil)



[Skin friction along the pile depth]

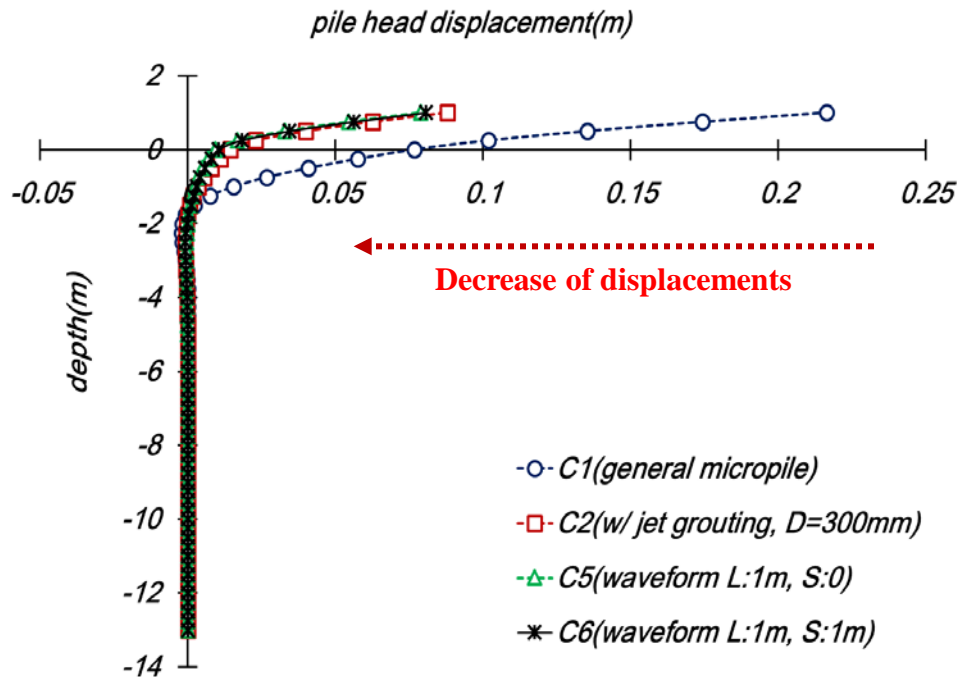


Analysis results

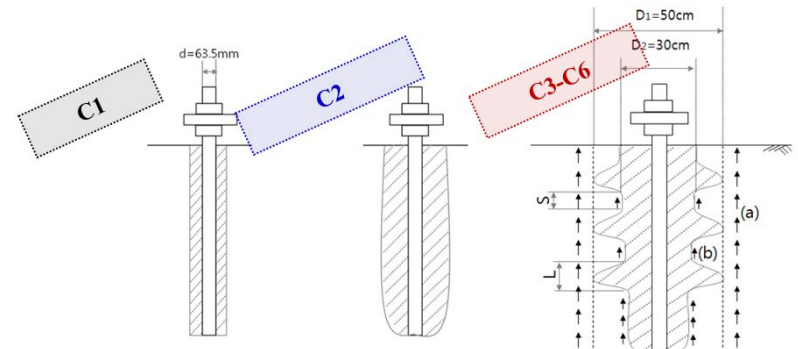
- Lateral bearing capacity

- Lateral displacement of C5(60%) < displacement of C1
- Decrement of lateral displacement at C5, C6: about **10% less than C2**

(effect of diameter > shear key)



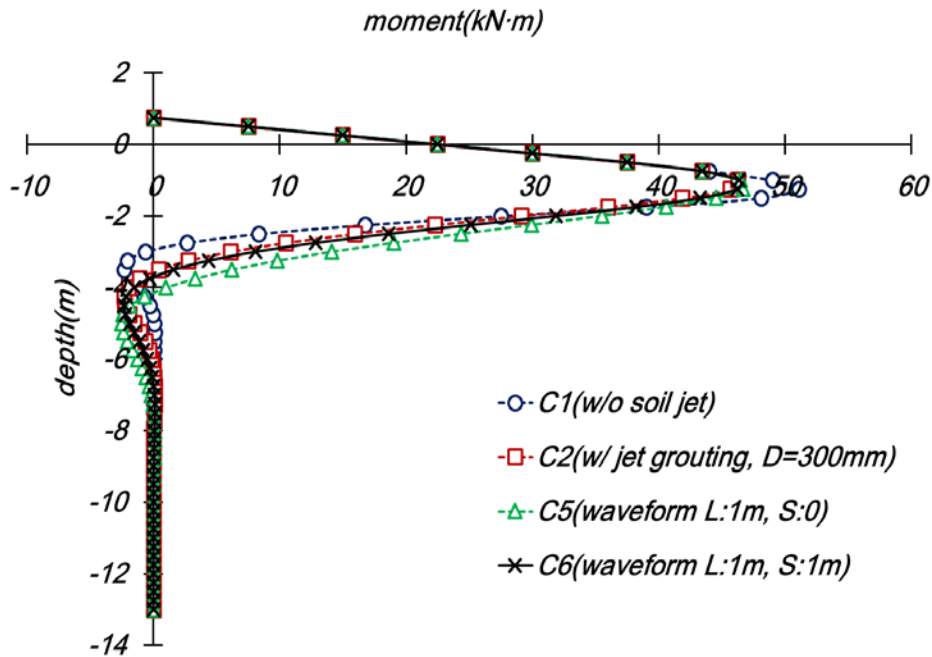
[Lateral displacement, p=30kN]



Analysis results

- Lateral bearing capacity

- Max. compressive stress: C1(89.2MPa), C2(17.5MPa), C5 & C6(3.8MPa)
- Waveform micropile : **compressive strength** ↓, higher bearing capacity



[Pile lateral displacement, moment, compressive strength]

Case	$\delta_{max}(m)$	$M_{max}(kN \cdot m)$	$\sigma_{max}(Mpa)$
C1	0.216	51.1	89.2
C2	0.088	46.3	17.5
C5	0.079	46.7	3.8
C6	0.081	46.3	3.8

Decreases

Decreases

[Moment, p=30kN]

Conclusion & future work

- **Conclusion**

- Waveform micropile

- :higher bearing capacity compared to the general micropile

- Vertical bearing capacity: increases as the length of the shear key ↑, space ↓

- Lateral bearing capacity: affected by shear key less

- **Future work**

- Laboratory test: to determine the optimal shape & w/c ratio for the grout body

- Filed test

- 1. Determination of waveform shape: shape for the better performance

- 2. Evaluation of constructability

- 3. Investigation the effects of various soil condition

Thank you!

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