ISM 14TH INTERNATIONAL WORKSHOP FOR MICROPILES
GOLD COAST AUSTRALIA - AUGUST 21-23 2019

ISCHEBECK TITAN

IGtH Institut für Geotechnik
Leibniz Universität Hannover

REINFORCEMENT OF EXISTING DEEP FOUNDATIONS WITH MICROPILES

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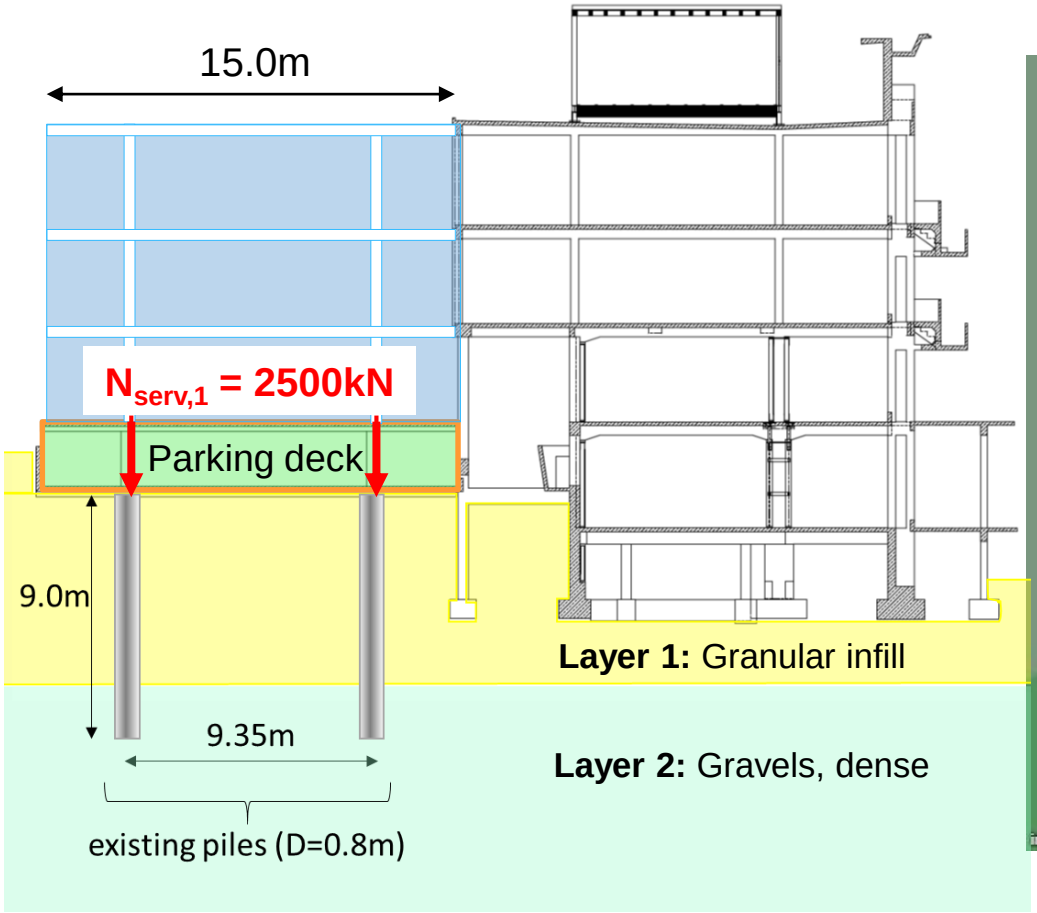
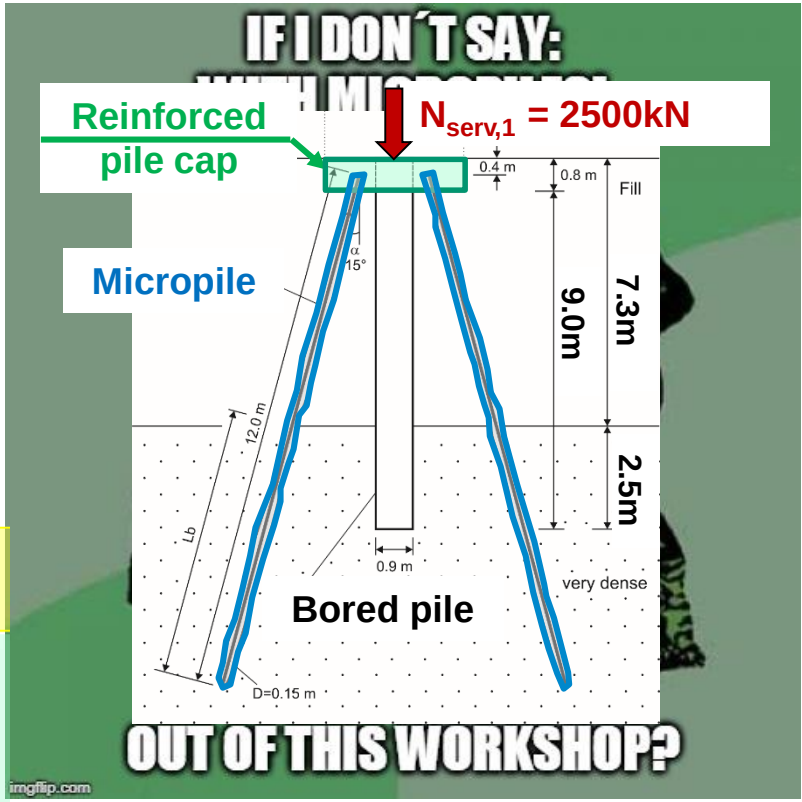
PROJECT DESCRIPTION: THE *AGGRIPABAD* IN COLOGNE, GERMANY

Intervention of the parking deck (with one underground level) of a public indoor swimming pool.

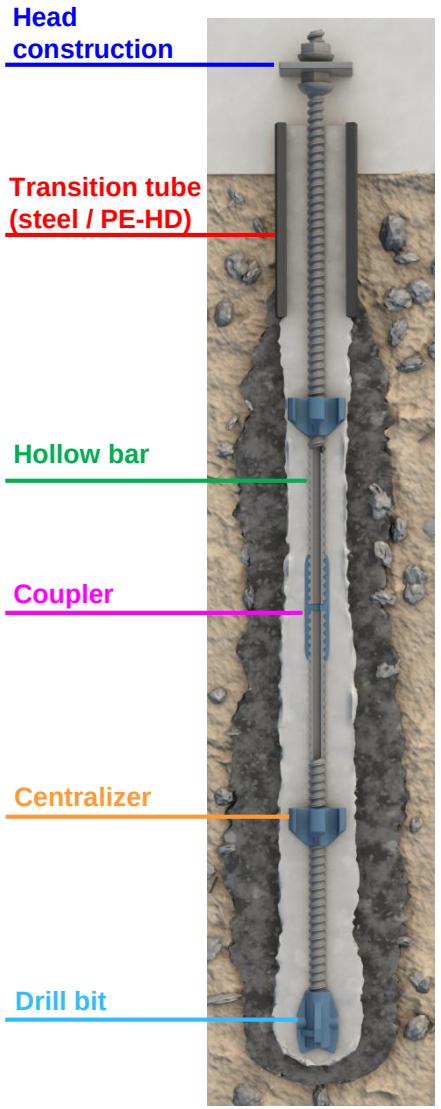
In order to expand the capacity of the existing facilities, different upgrading and extension measures are planned.



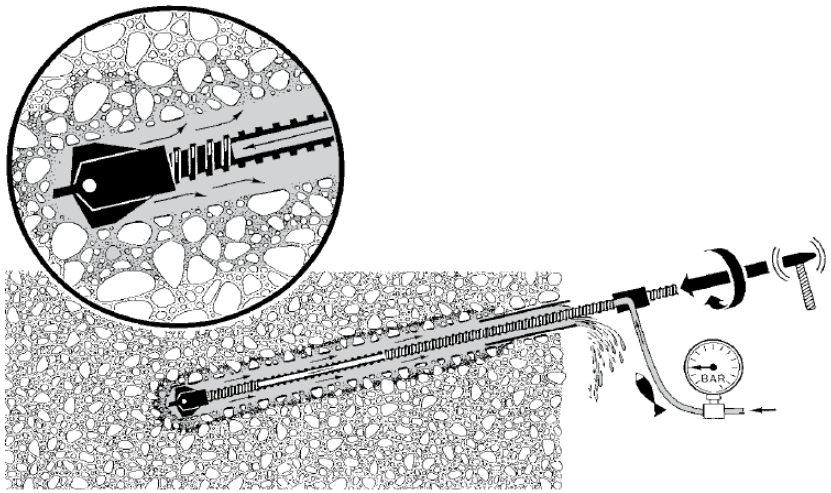


UNDERPINNING WITH SELF-DRILLING MICROPILES

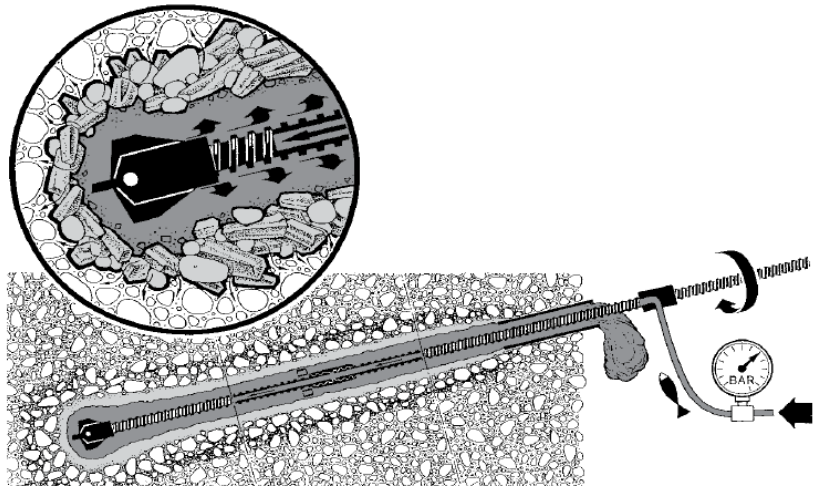
COMPONENTS



INSTALLATION PROCESS



Rotary-percussive drilling with flushing grout (w/c = 0.7 – 0.8)



Dynamic pressure grouting (w/c =0.4 – 0.5)

ADVANTAGES

High drilling performances with low vibrations

Flexible use of drilling equipment

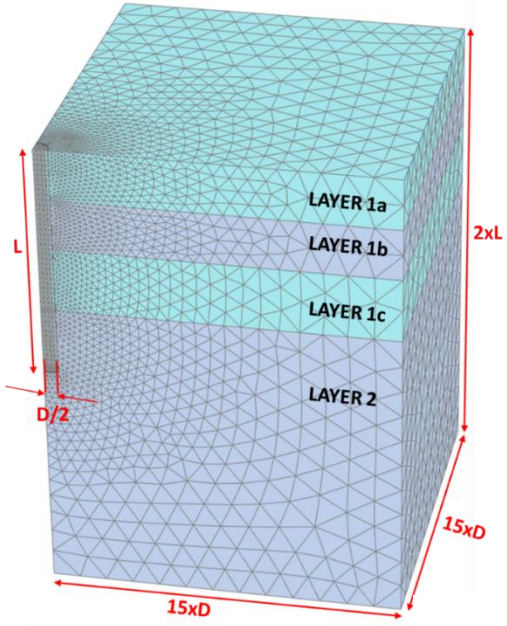
Installation even in confined spaces

ANALYSIS OF THE REINFORCED PILE FOUNDATION

There is no analytical method to evaluate the interaction between the existing piles an the reinforcement, specially in terms of **settlement compatibility**.

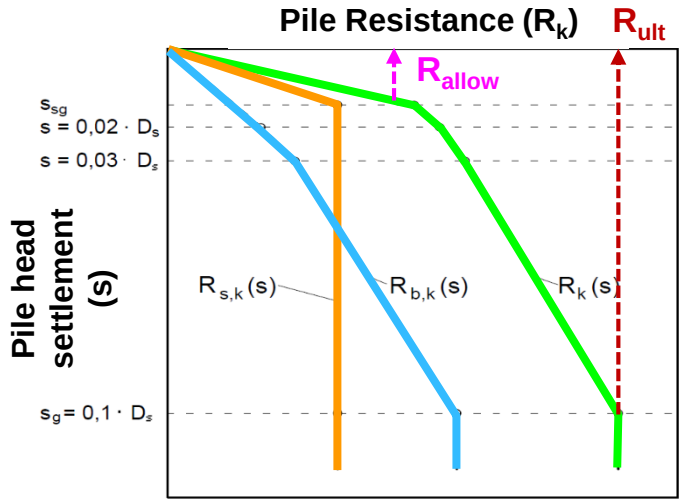
The evaluation was carried out with a 3D-FEM model (PLAXIS) of the reinforced pile foundation system

Preliminary analysis were carried out to assess the behavior of the single piles, comparing the results of the numerical simulations with those of the analytical models acc. to the German practice (EAP2012 + DIN EN 1997-1-1):



Model geometry: 3D / axisymmetric
Pile: volume elements (concrete), lineal-elastic
Soil: HSsmall

Numerical Model (PLAXIS3D)



$$R_{k(s)} = R_{b,k(s)} + R_{s,k(s)}$$

$$R_{b,k(s)} = \frac{\pi}{4} * D * q_{b,k(s)}$$

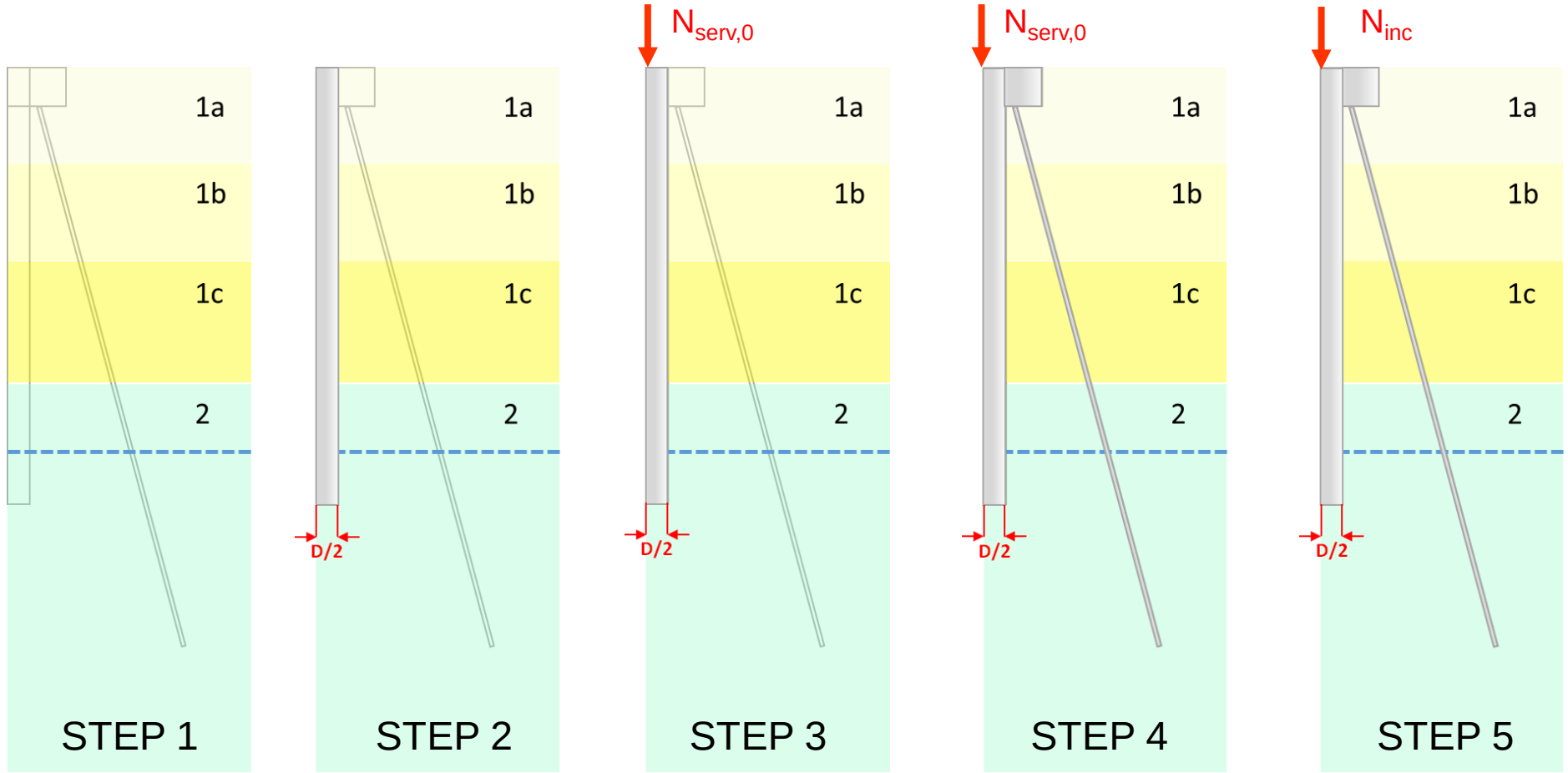
$$R_{s,k(s)} = \pi * D * \sum q_{s,k,i} * L_i$$

$$R_{allow} = \frac{R_{ult}}{FS}$$

Analytical Model (Recommendations on Piling, EAP 2012)

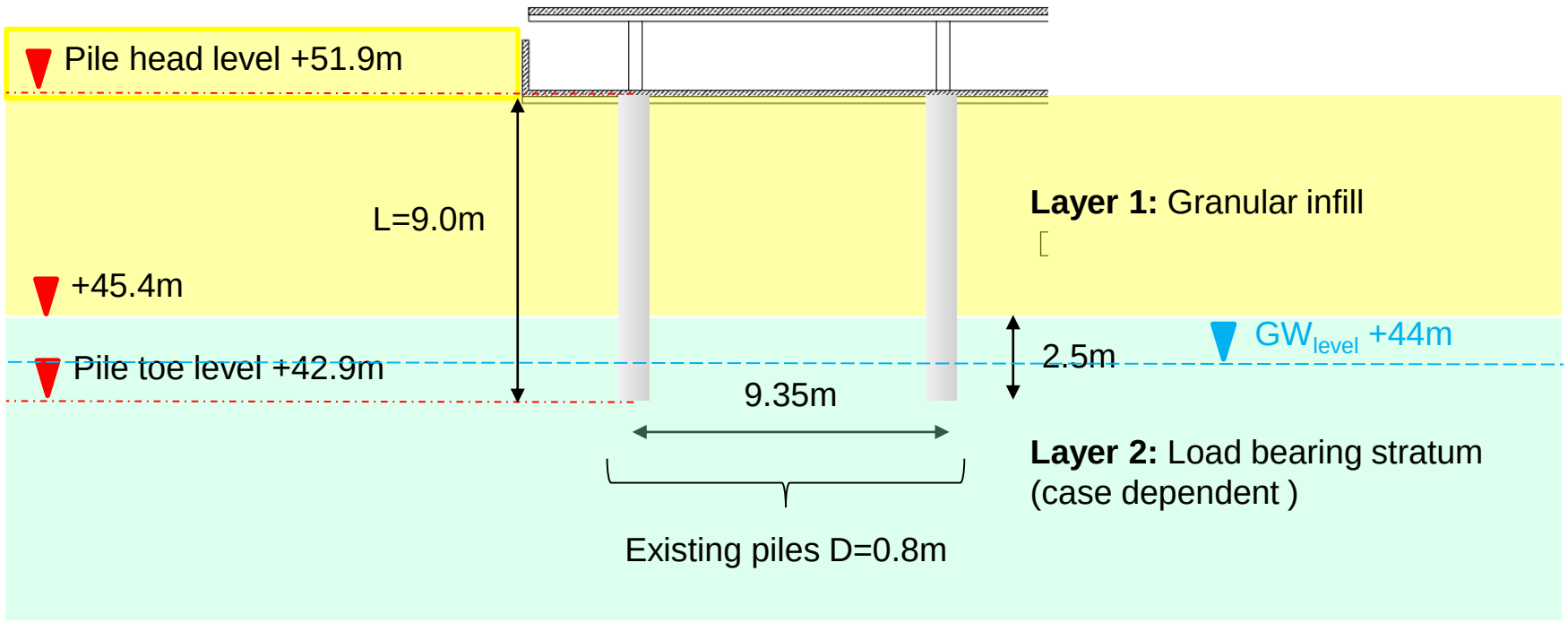
ANALYSIS OF THE REINFORCED PILE FOUNDATION

After calibrating the numerical models to simulate the behavior of the single piles, the interaction between the elements of the reinforced foundation (pile and micropiles) was evaluated:



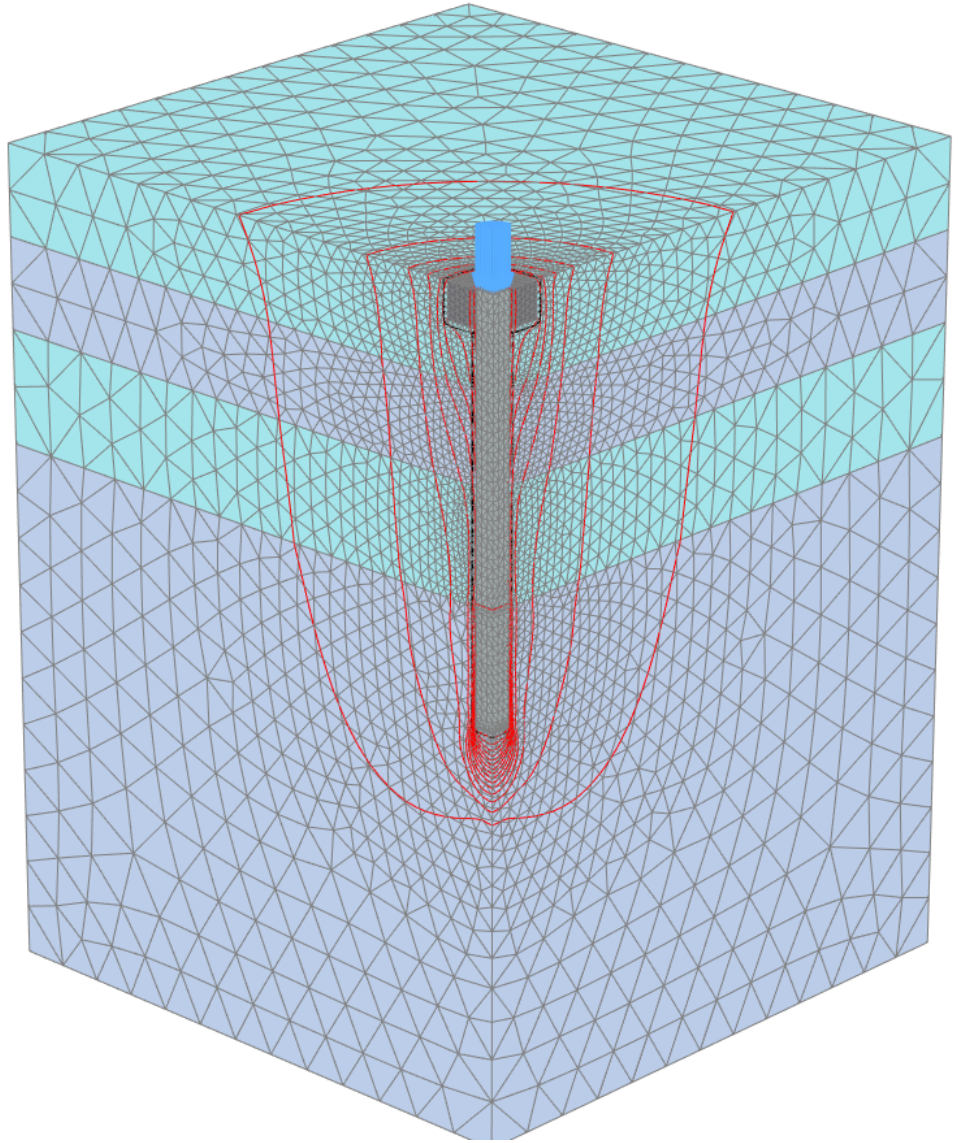
PARAMETRIC STUDY

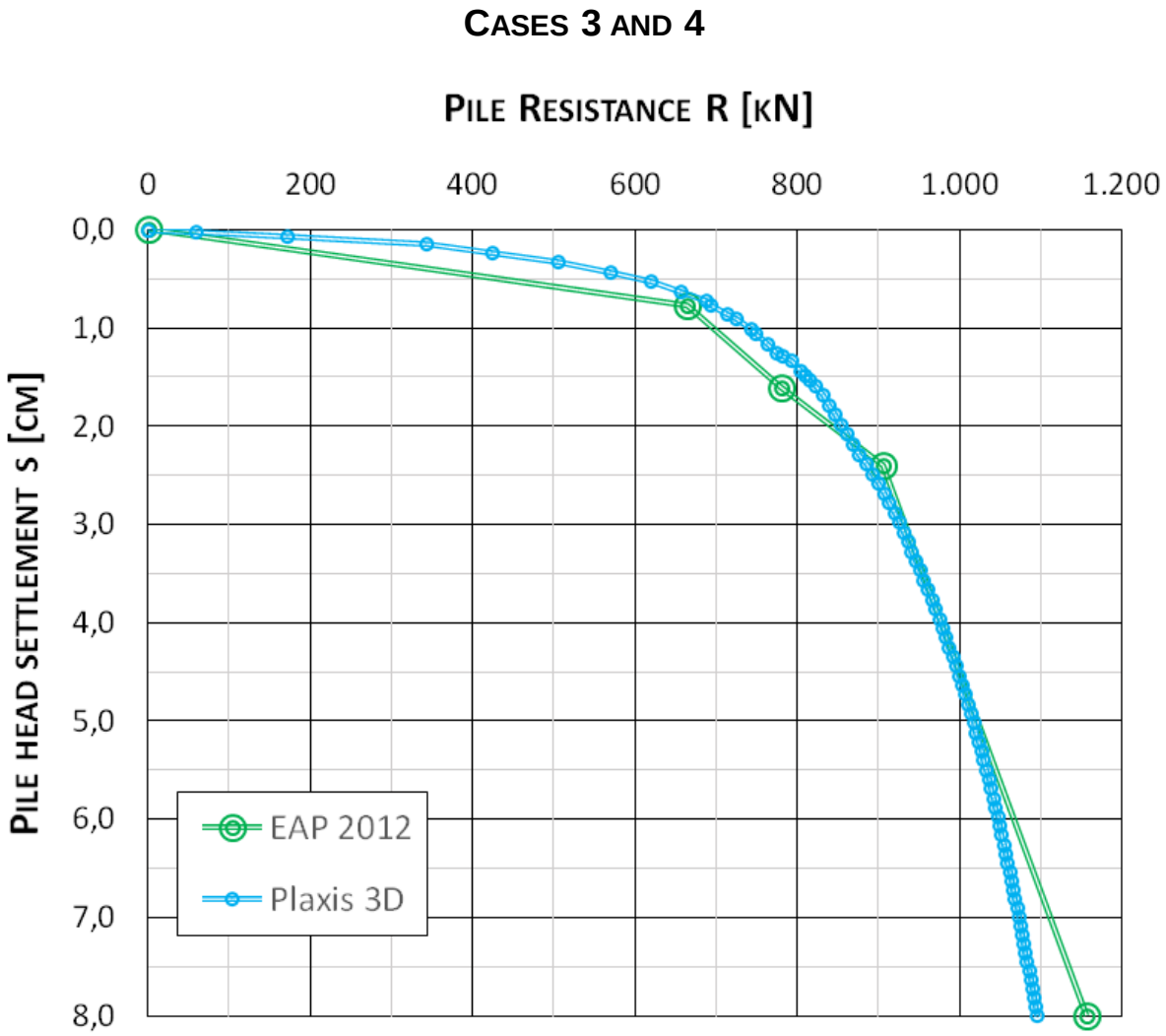
Three different ground conditions with different geotechnical properties were assigned to the load bearing stratum:



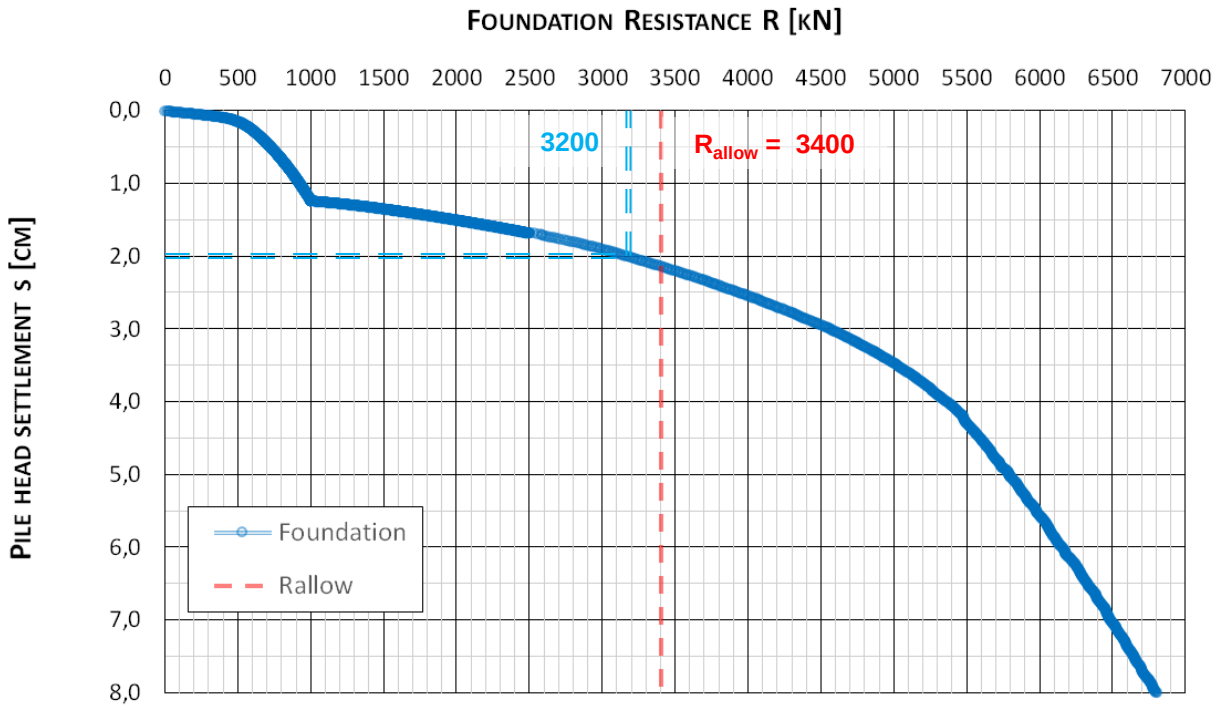
Case	Layer 2
1	**Gravels**, medium dense to dense (q_c = 14 MN/m^2)
2	**Sands**, medium dense (q_c = 11 MN/m^2)
3 and 4	**Clays**, firm – stiff ($c_{u,k}$ = 150 kN/m^2)

Analysis of the single piles

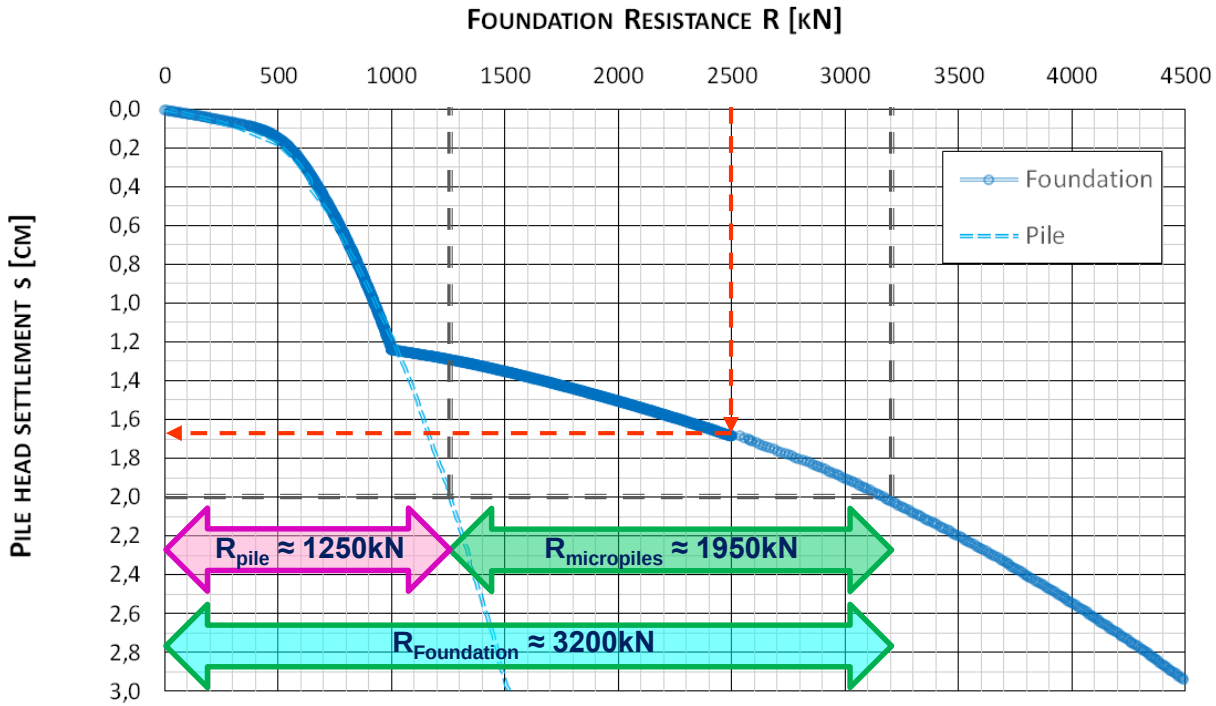




Analysis of the Reinforced Foundation: Case 1 (Gravels, Micropile´s length = 12m)

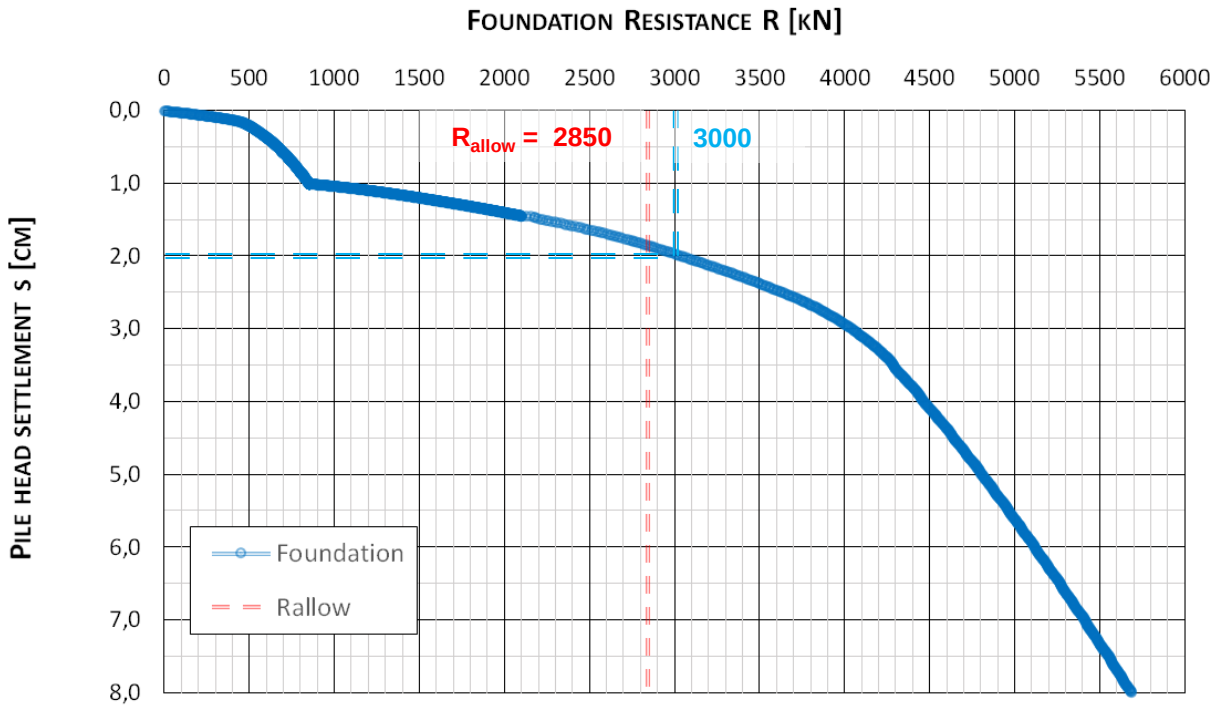


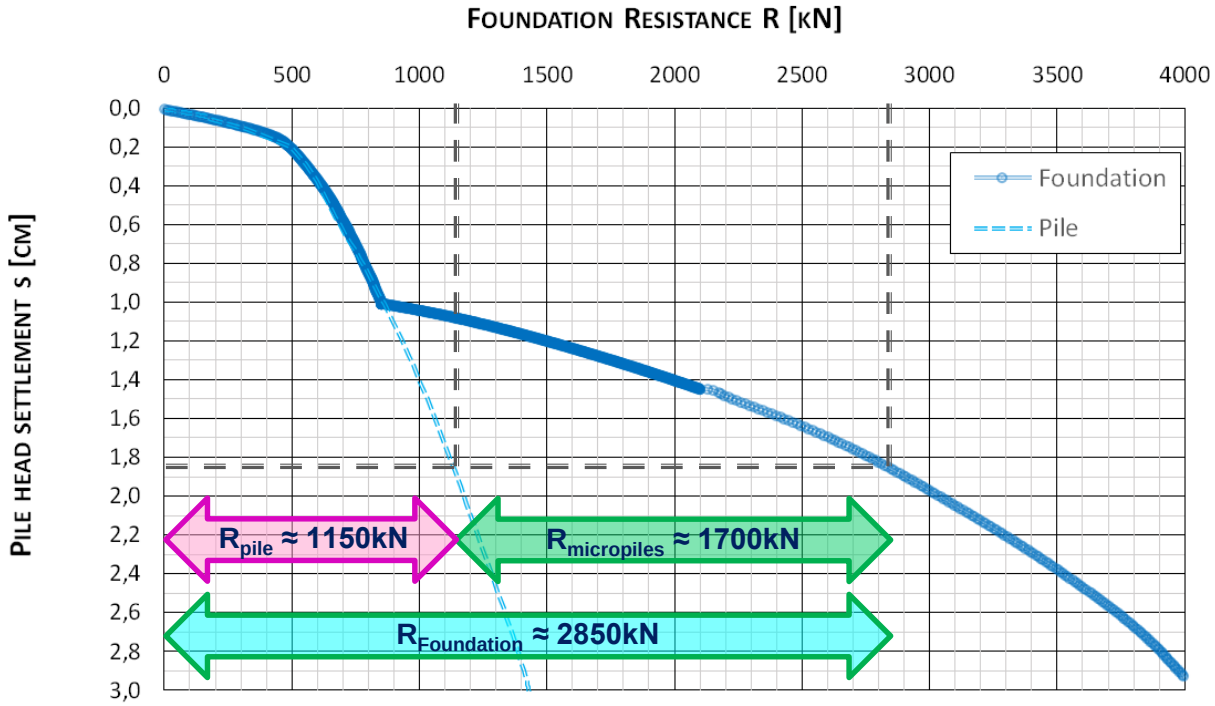
s = 1.7cm is expected for $N_{serv,1}$ = 2500kN



$$\frac{R_{Foundation}}{R_{pile}} = \frac{3200kN}{1250kN} = 2.56$$

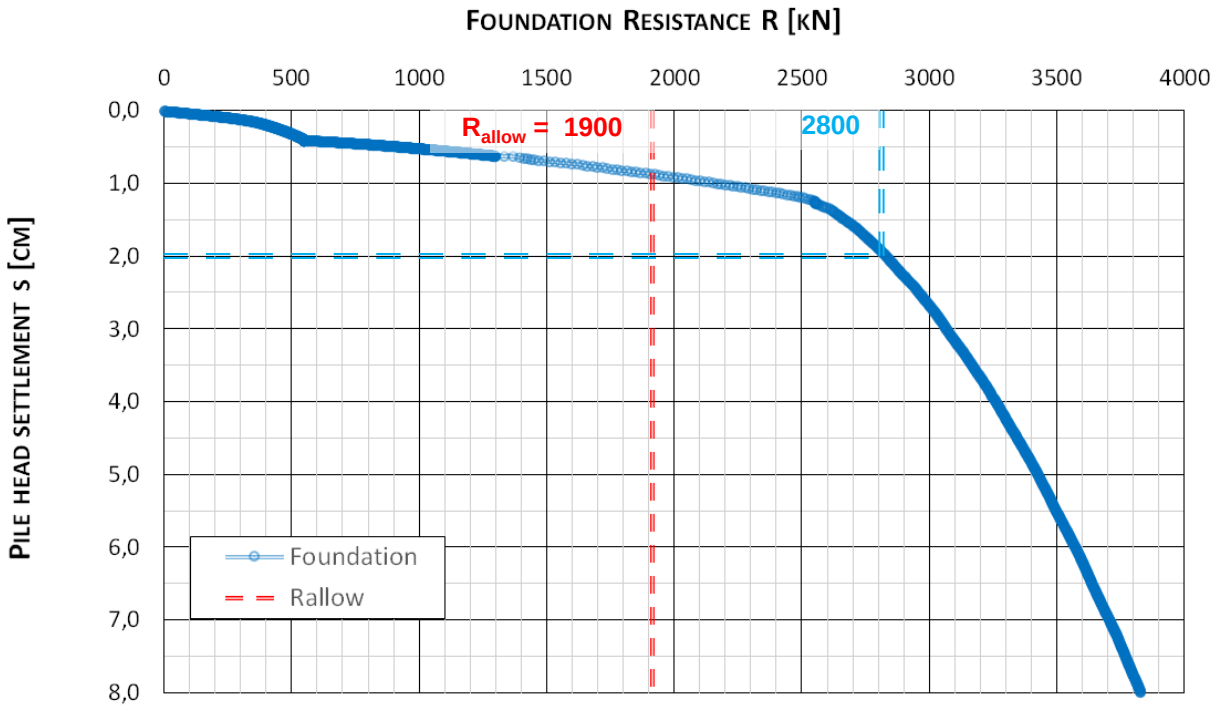
Analysis of the Reinforced Foundation: Case 2 (Sands, Micropile´s length = 12m)

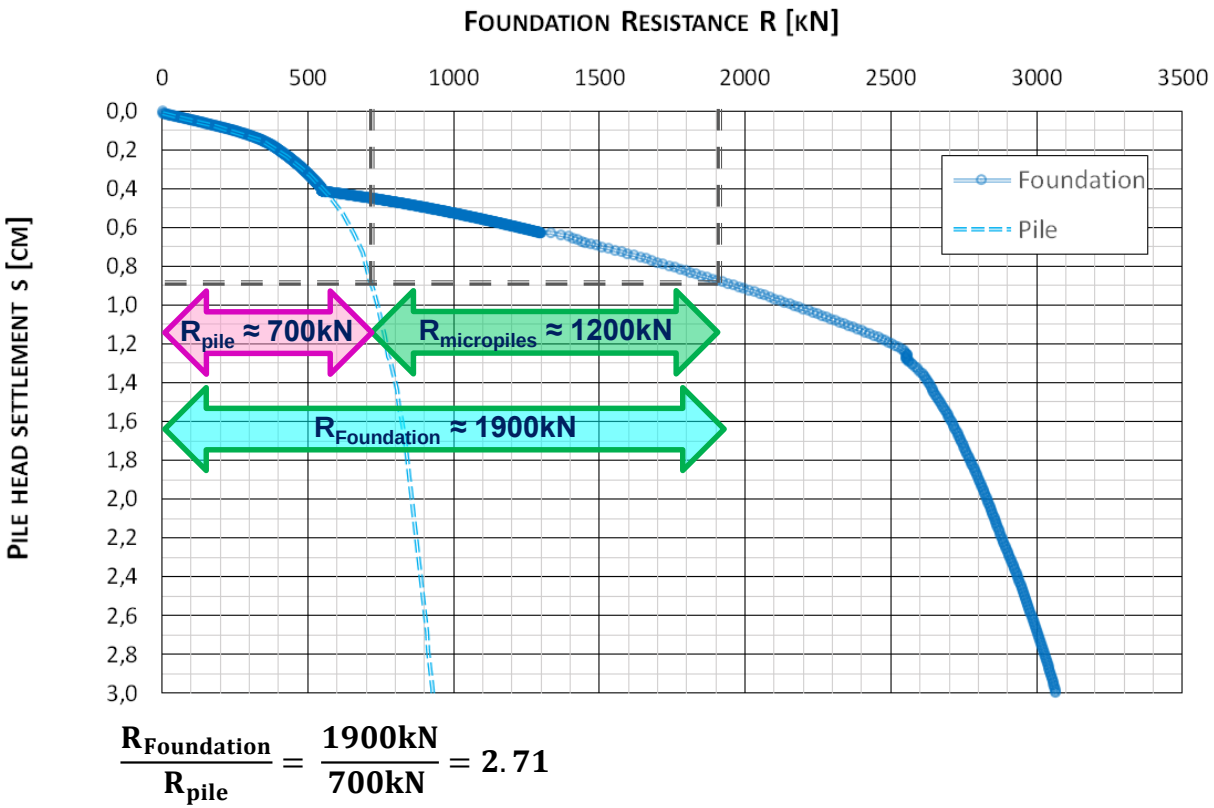




$$\frac{R_{Foundation}}{R_{pile}} = \frac{2850kN}{1150kN} = 2.48$$

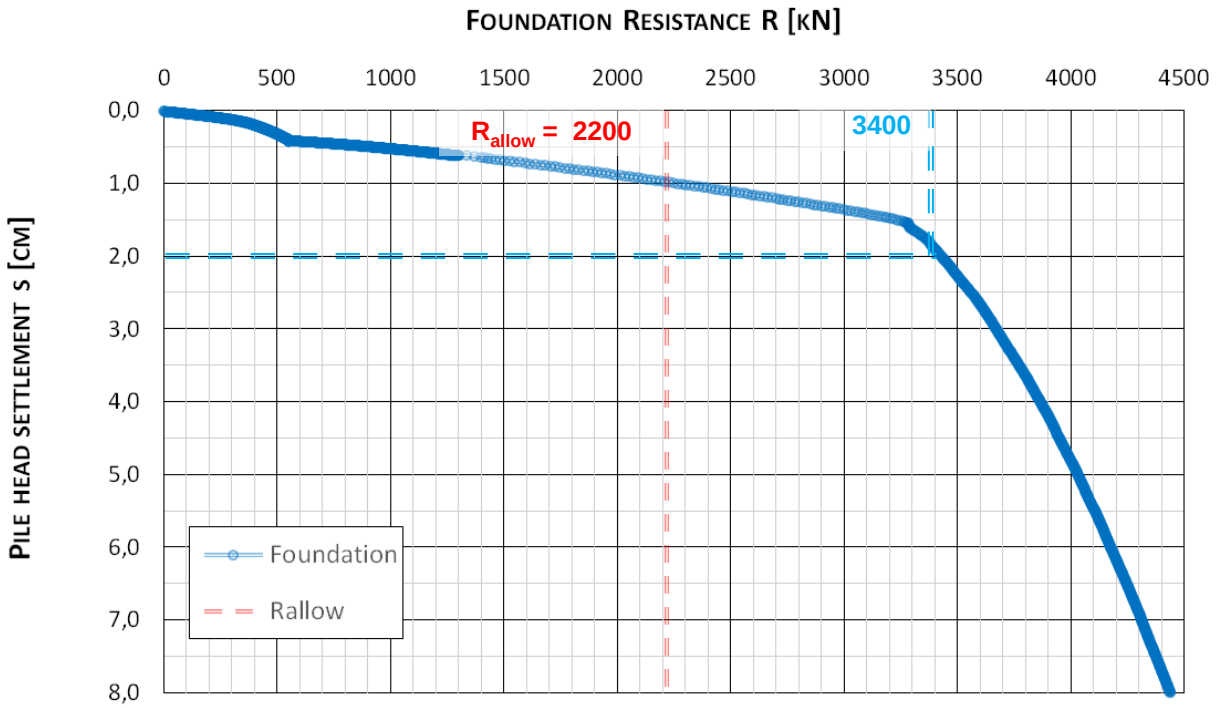
Analysis of the Reinforced Foundation: Case 3 (Clay, Micropile´s length = 12m)

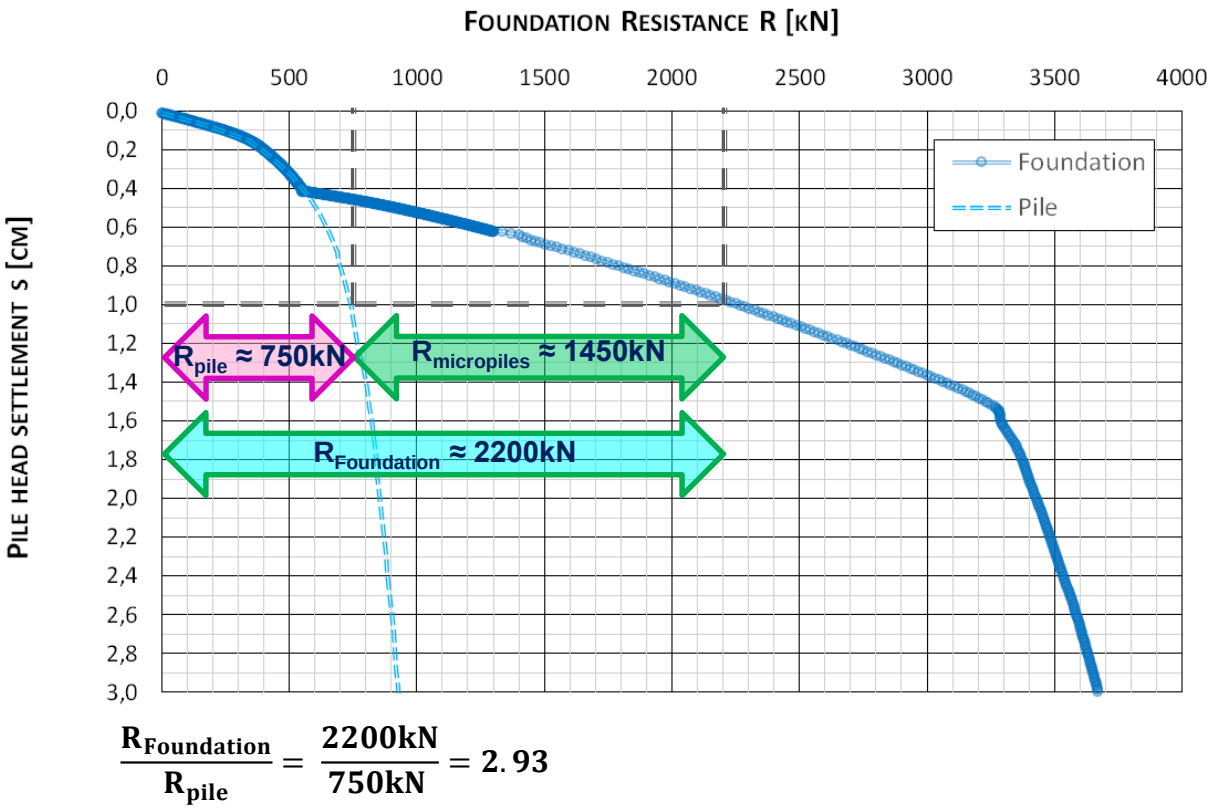




$$\frac{R_{Foundation}}{R_{pile}} = \frac{1900kN}{700kN} = 2.71$$

Analysis of the Reinforced Foundation: Case 4 (Clay, Micropile´s length = 15m)





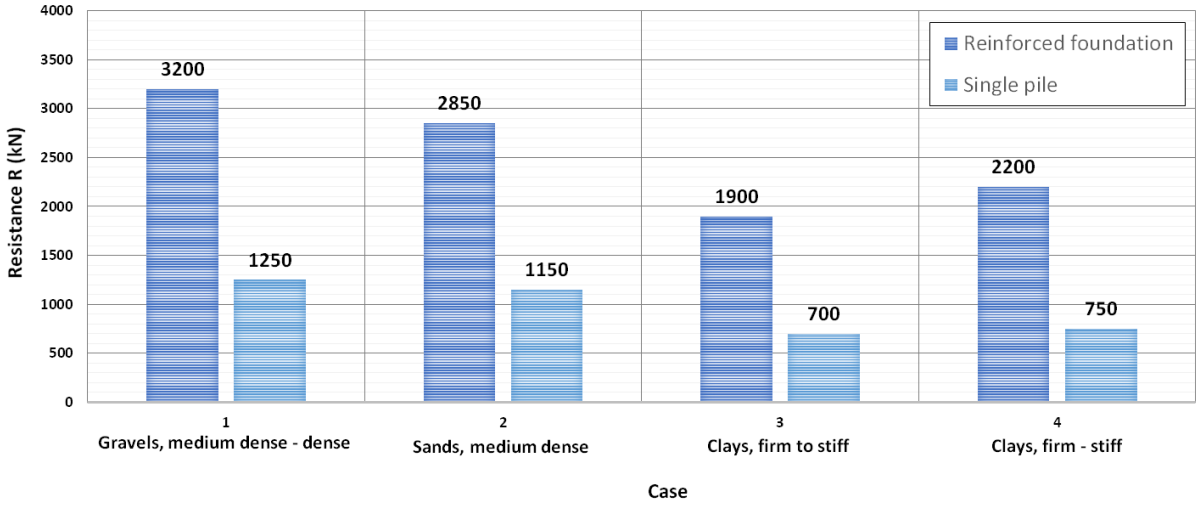
$$\frac{R_{Foundation}}{R_{pile}} = \frac{2200kN}{750kN} = 2.93$$

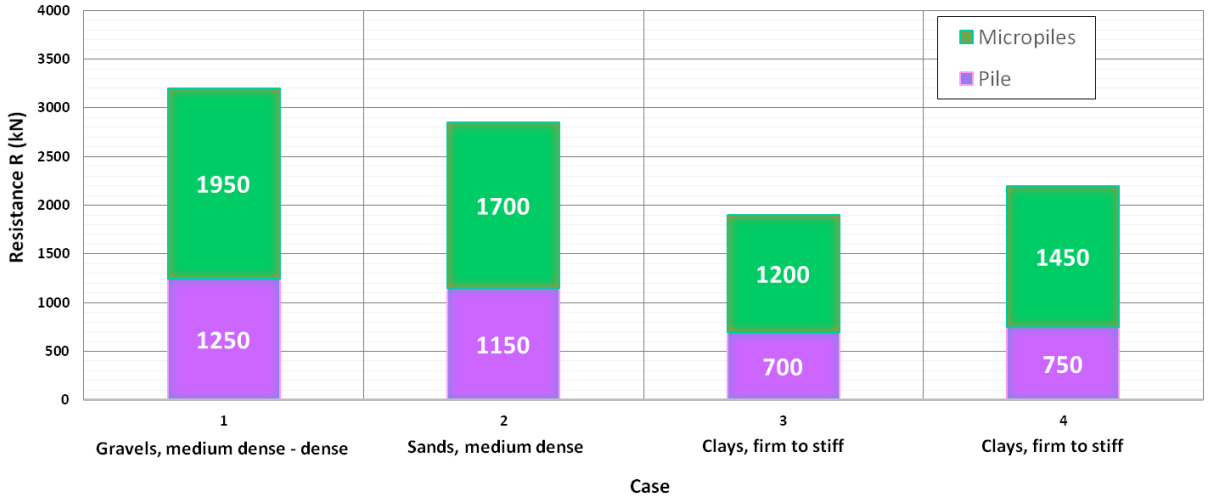
SUMMARY AND CONCLUSIONS

A group of symmetrically arranged self-drilling micropiles (15° vertical inclination) was proposed to reinforce an existing pile foundation, in order to increase its load bearing capacity.

A parametric study was conducted, using numerical models (PLAXIS3D) to evaluate the interaction of the existing pile foundation and the reinforcement, considering three different ground conditions.

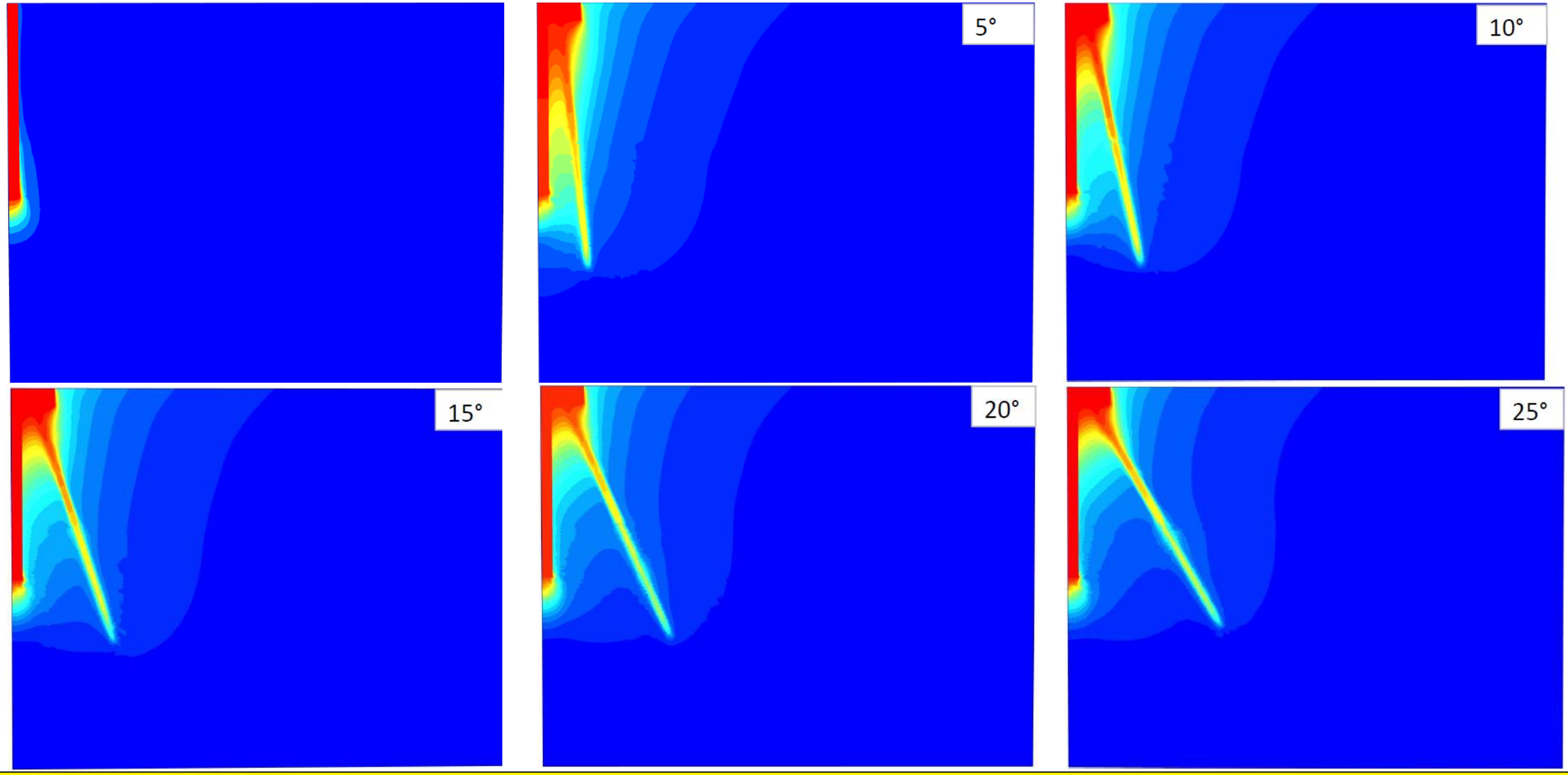
For the same settlements (up to 2.0cm), the load bearing capacity of the reinforced foundation is significantly improved (>2.5 times the capacity of the single piled foundation). The contribution of the micropiles is evident, representing more than 60% of the total resistance.



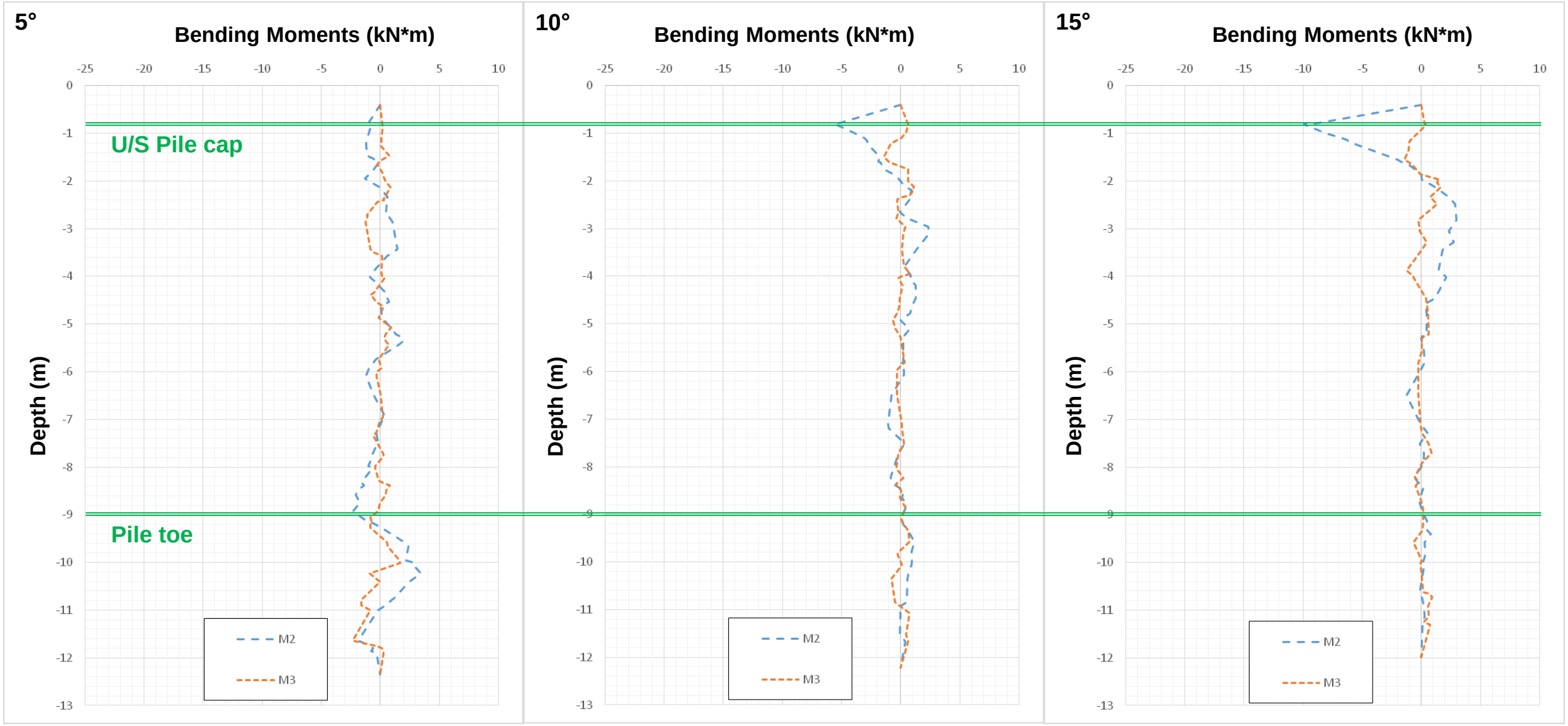


FURTHER ANALYSIS

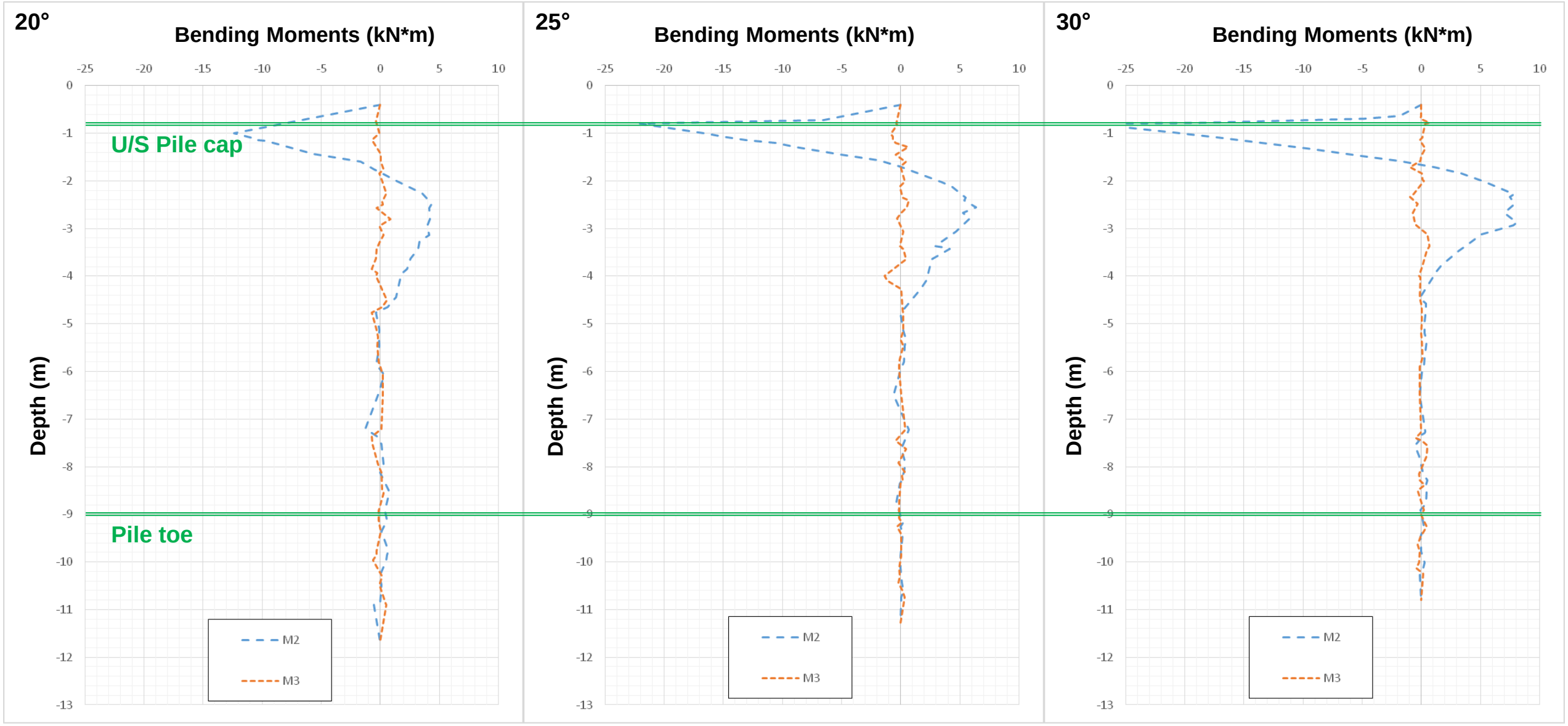
Reinforced Foundation: Influence of the inclination of the micropiles (Case 1)



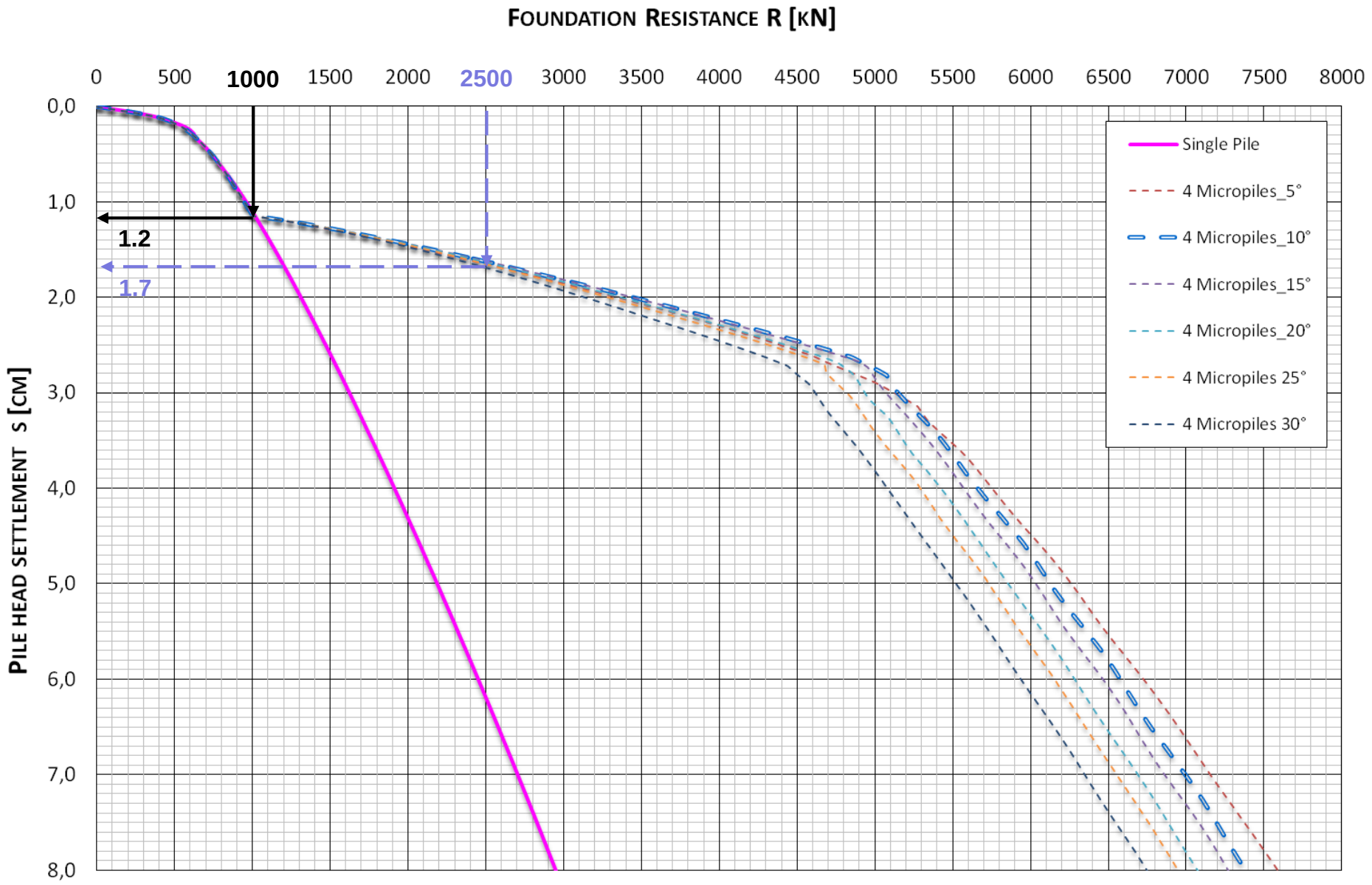
Reinforced Foundation: Influence of the inclination of the micropiles (Case 1)



Reinforced Foundation: Influence of the inclination of the micropiles (Case 1)



Reinforced Foundation: Influence of the inclination of the micropiles (Case 1)

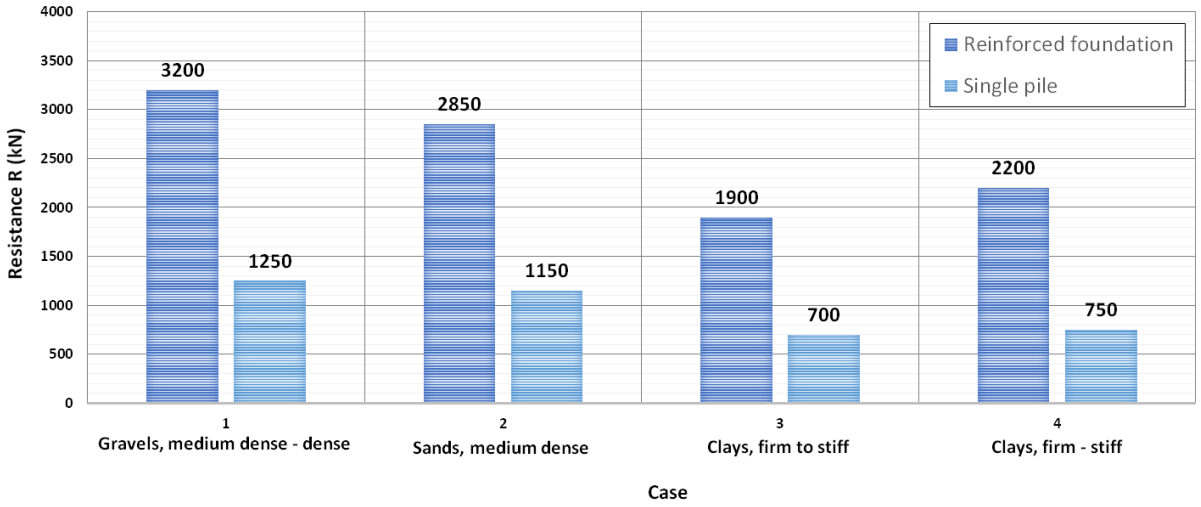


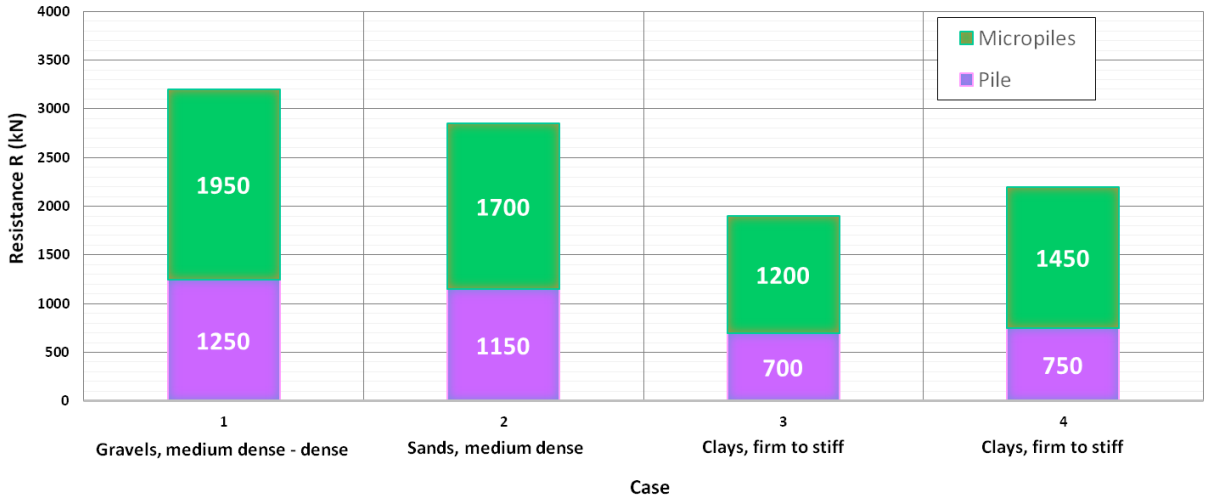
SUMMARY AND CONCLUSIONS 2.0

A group of symmetrically arranged self-drilling micropiles (10° vertical inclination) was proposed to reinforce an existing pile foundation, in order to increase its load bearing capacity.

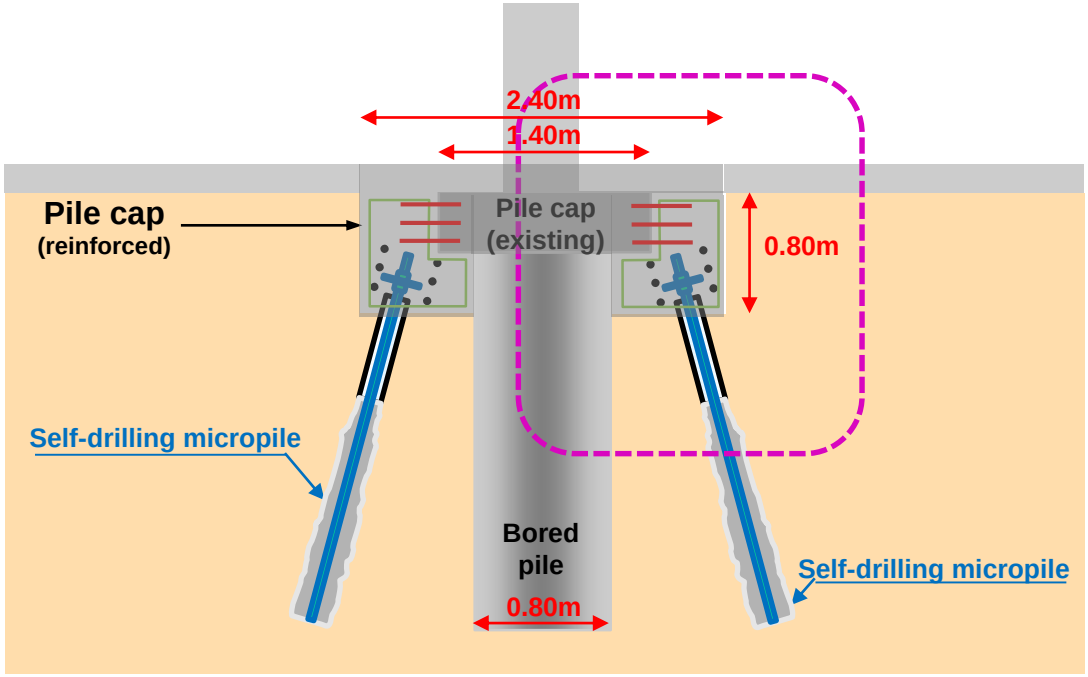
A parametric study was conducted, using numerical models (PLAXIS3D) to evaluate the interaction of the existing pile foundation and the reinforcement, considering three different ground conditions.

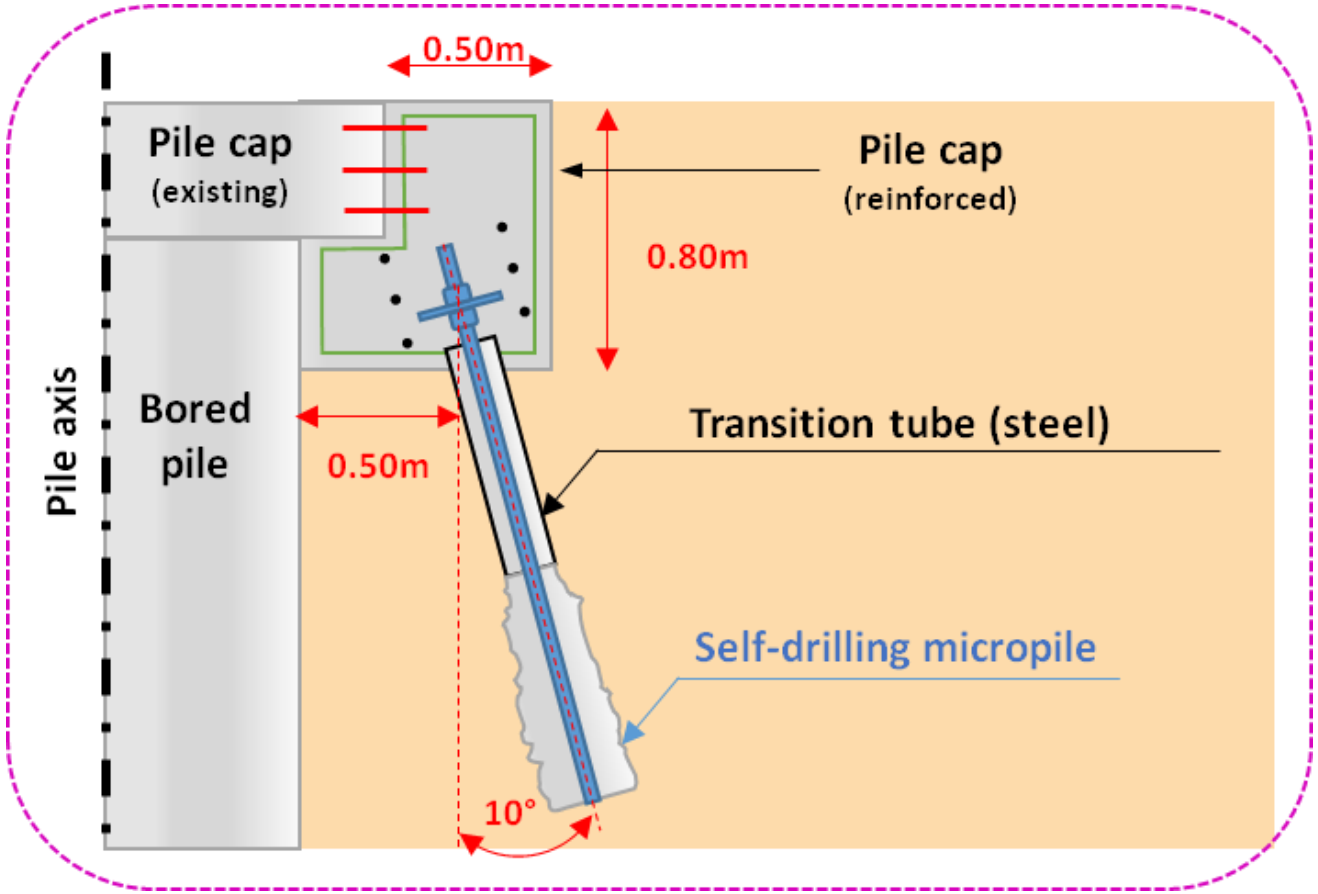
For the same settlements (up to 2.0cm), the load bearing capacity of the reinforced foundation is significantly improved (>2.5 times the capacity of the single piled foundation). The contribution of the micropiles is evident, representing more than 60% of the total resistance.





The following constructive sequence can be proposed:





AKNOWLEDGMENTS

To my co-authors: Mr. Jann-Eike Saathoff and Prof. Martin Achmus (IGtH – Leibniz University of Hannover)

To the ISM and the Organization Committee of the 14th International Workshop for Micropiles

To you for your kind attention

LET´S MAKE SOUTH AMERICA GREAT AGAIN! VOTE FOR US IN THE WORLD CUP OF MICROPILES!

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