tfeg

COMPRESSED ELEMENTS WITH TFEG TECNOLOGY: from research to design

Innsbruck, February 24th 2009

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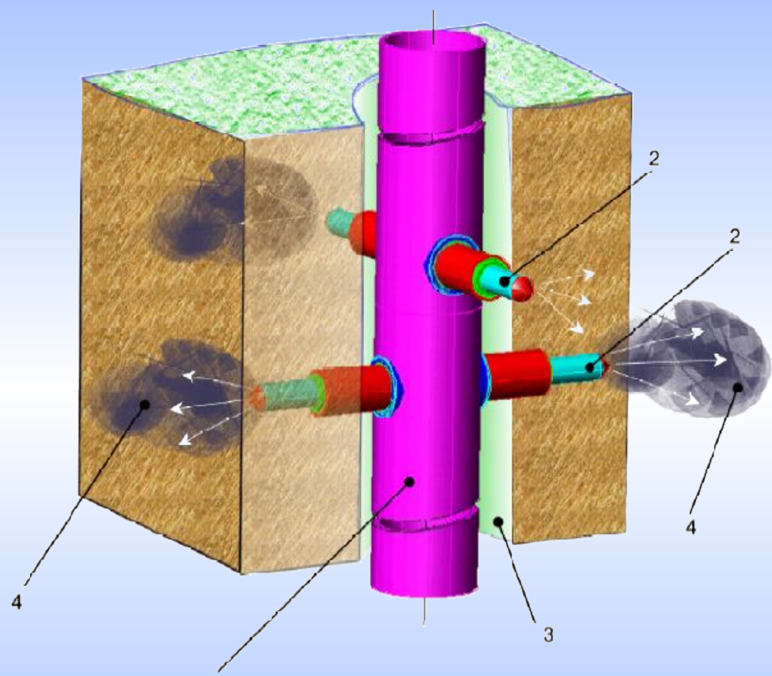
JobSoil
INNOVATION & RESEARCH

THE TECNOLOGY



TFEG

THRIVING FRICTION by EXTRUDING GEAR

The system consist in the insertion, along pile, micropile or tie rod shaft, of steel sockets in the soil to increase the bonding surface between the pile system and the surrounding soil.

The steel sockets are placed at predetermined design level and pressure driven with hydraulic system .

THE RESEARCH

PAST

- **Micropile**: experimantal field in Teano (CE) and S. Giovanni a T. (NA) - South Italy
- **Tied rod:** experimantal field in Rome EUR, Salerno, San Giuliano di Puglia ecc.
- FEM simulation
- Formulation of “simple” model

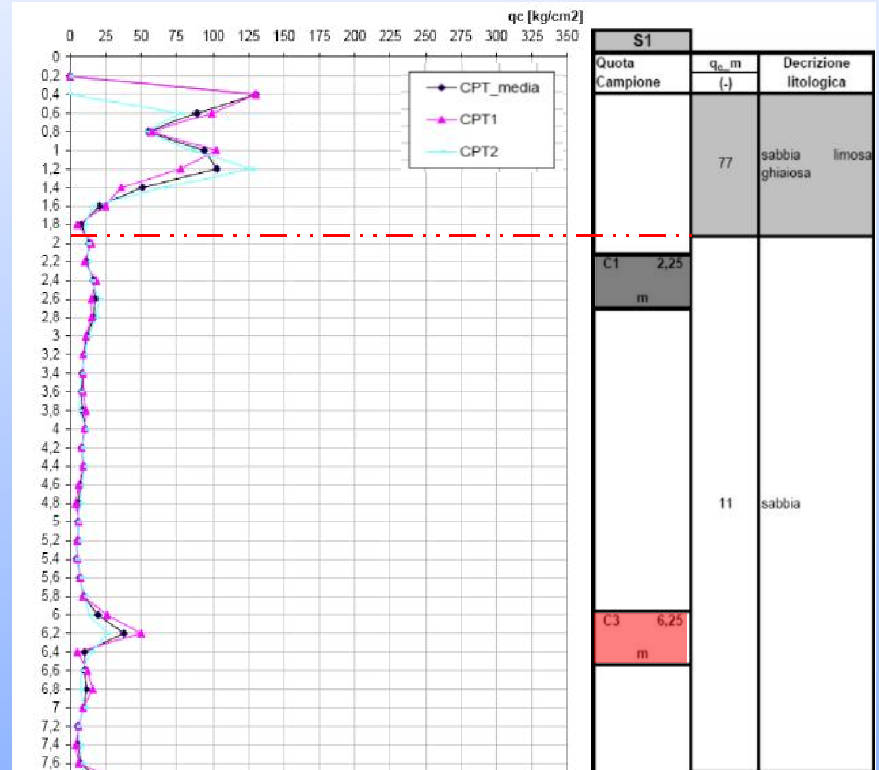
Future-Present

- Collaboration with University of Salerno
- Experimentation in centrifug e laboratory simulation at “ reduced scale”
- New “simple” formulation based on the plasticity theory

Experimental field S.G.T.

Experimental field financed by Italian University Department (***M.I.U.R)***

- Definition of the ***geotechnical model*** with:
  - 2CPT
  - 1 Core boring with 7 undisturbed samples
- Definition of the hydraulic condition:
  - No water table



FOLLOWS

Experimental field S.G.T.

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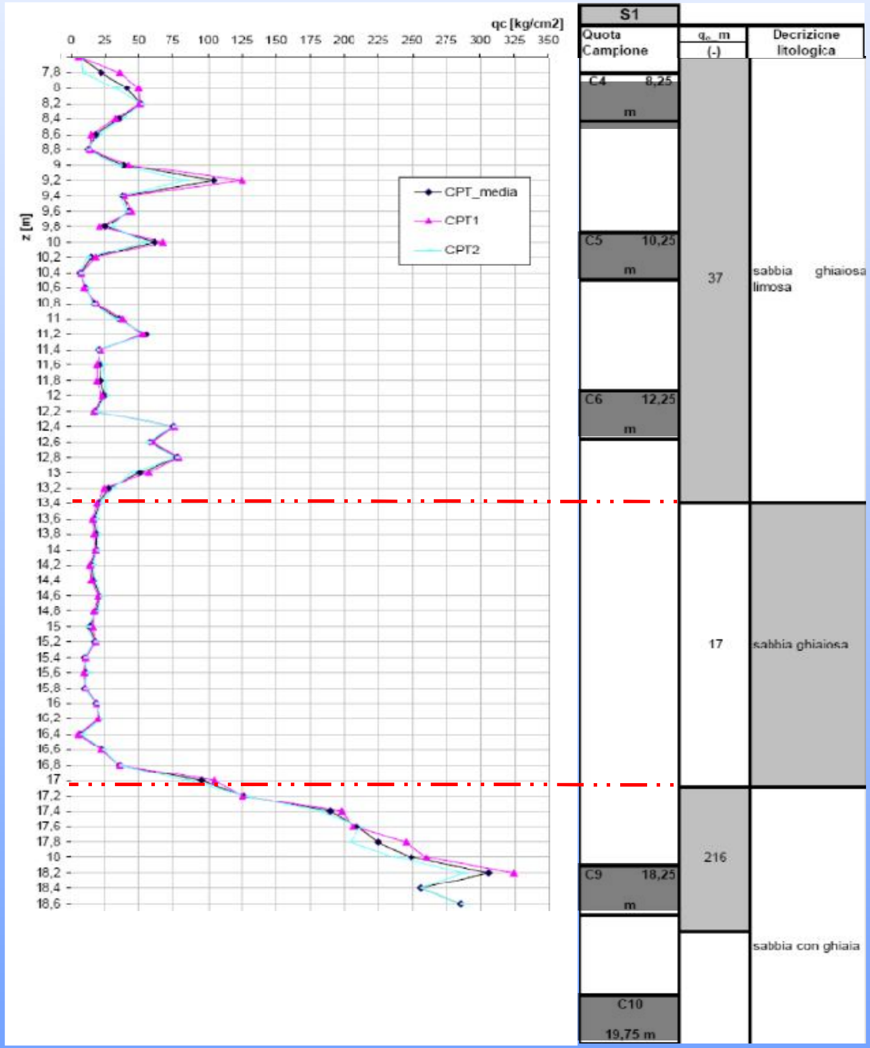


Experimantal field S.G.T.

<u>Geotechnical model</u>

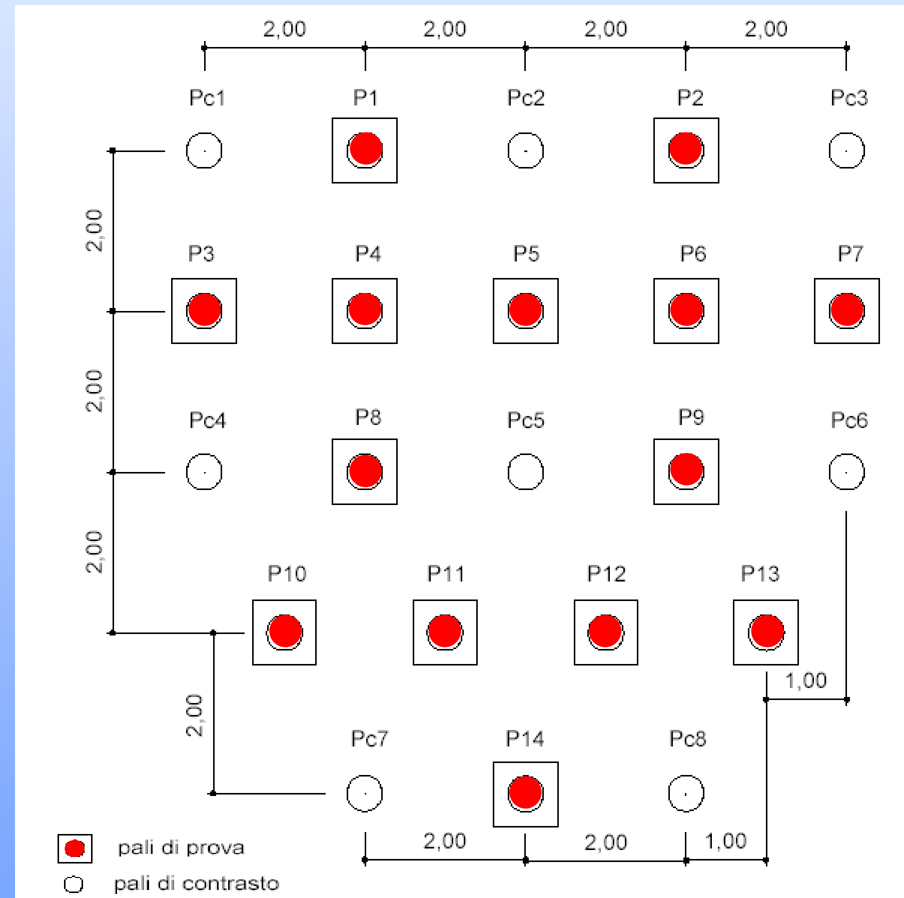
Soils variable from sandy silt to silty sand with gravel poorly dense

The stratigraphy is omogenus in the investigated area.

Experimantal filed of S.G.T.

Micropile D=220 mm

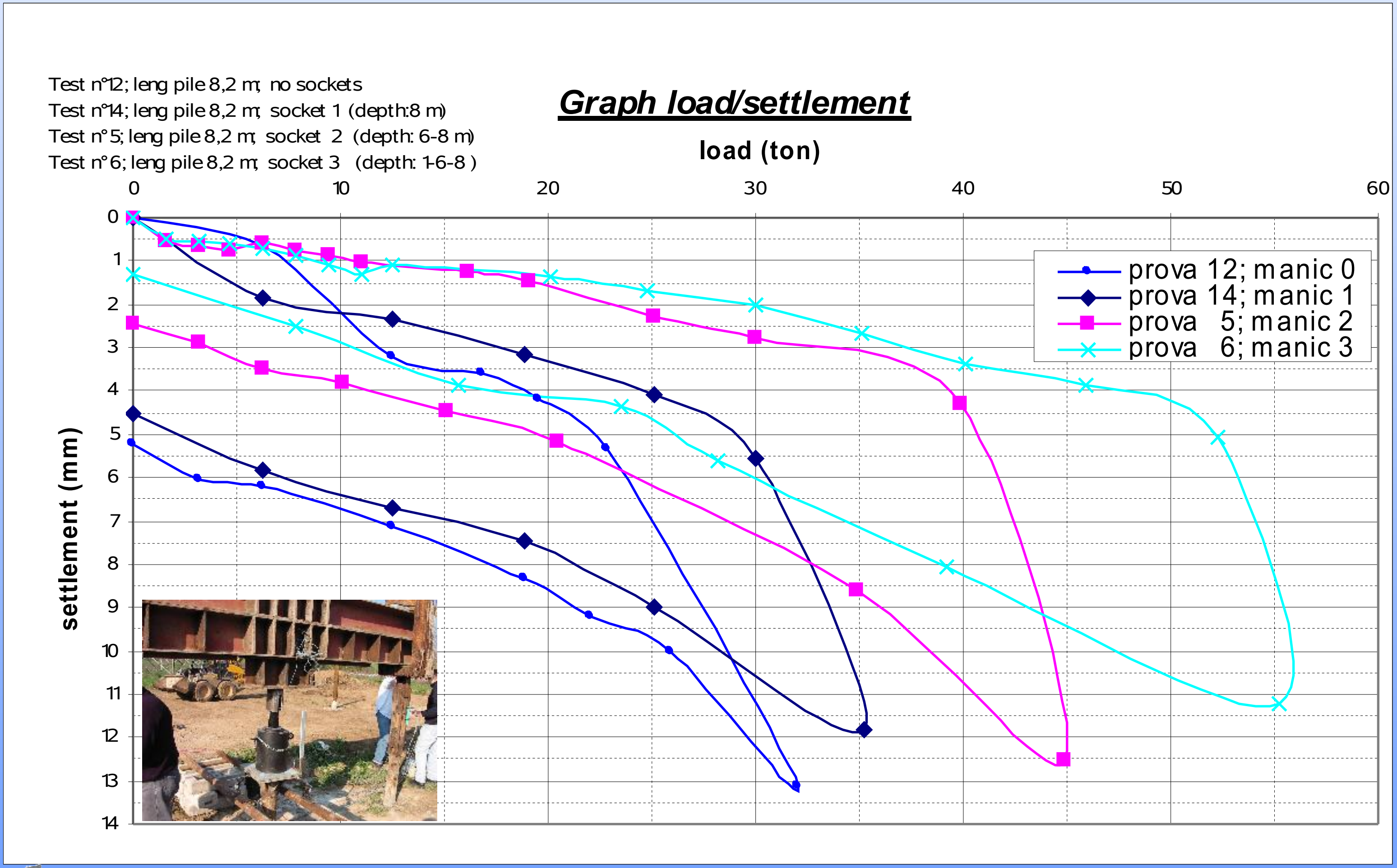
Test n°	L [m]	Number TFEG	Z_{TFEG} [m]	P_{ult} [kN]
3	3,7	0		210
2	3,7	1	1	396
10	3,7	2	1-3,5	448
11	6,2	0		274
4	6,2	1	6	341
8	6,2	2	1-6	495
12	8,2	0		398
14	8,2	1	8	375
5	8,2	2	1- 8	433
6	8,2	3	1-6-8	520
7	10,2	0		471
1	10,2	1	10	511
9	10,2	2	8-10	625
13	10,2	3	1-8-10	657



Increments of bearing capacity of the system variable from ***35-150%***

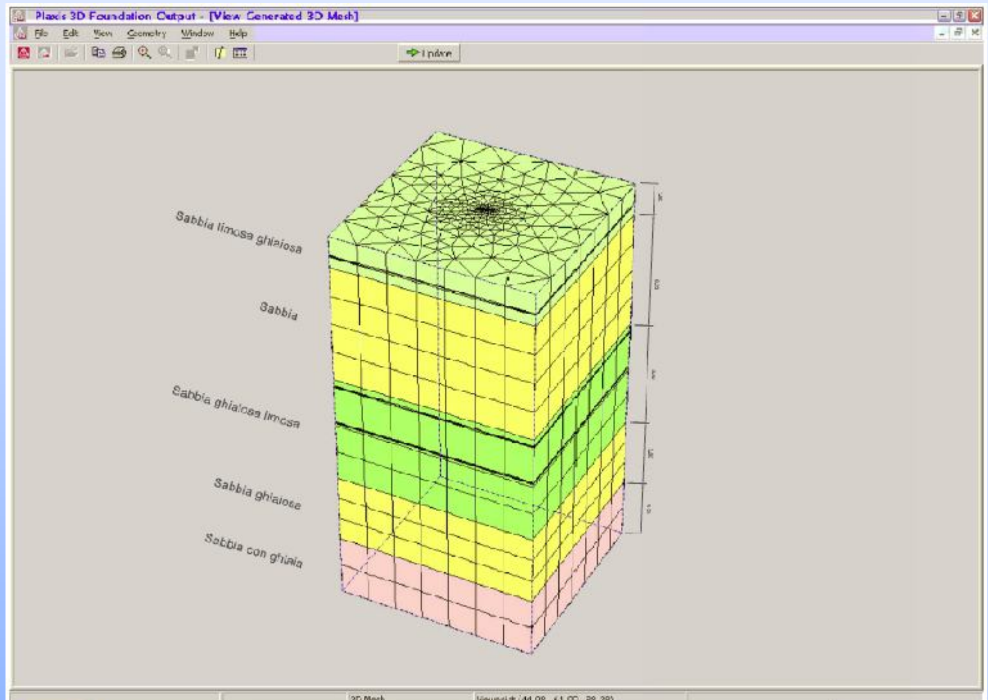
Experimantal filed of S.G.T.

*Increase of **bearing capacity** and **stiffness** of TFEG sistem*



FEM FIELD S.G.T.

Plaxis 3D Foundation



System TFEG+PILE

Linear elastic

Constitutive model of soil:

Mohr-Coulomb elastic-perfectly plastic

Menichelli 2007- Roma III

strato n°	definizione strato	γ [kN/m^3]	E(a) [Mpa]	φ [°]	ν [-]	R [-]	c [kPa]	profondità [m] da pc
1	Sabbia limosa ghiaiosa	16	22	33	0,3	0,5	42	1,6
2	Sabbia	17	400	37	0,3	1	0,1	7,6
3	Sabbia ghiaiosa limosa	14	500	34	0,3	1	2	13,2
4	Sabbia ghiaiosa	15,5	500	35	0,3	1	0,1	16,8
5	Sabbia con ghiaia	16	640	37	0,3	1	0,1	20

Compressed Elements with TFEG

PhD Ing. Giancarlo MIGLIARO

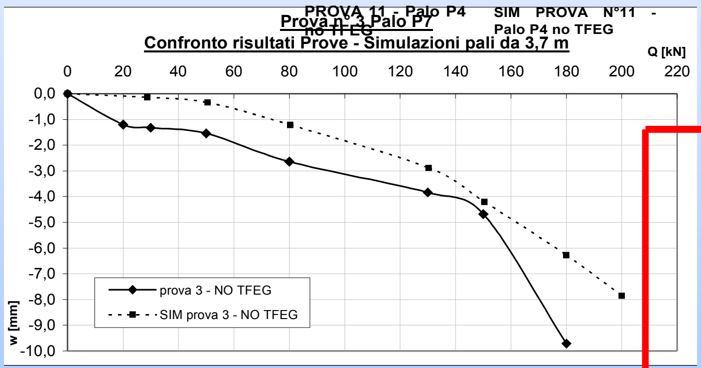
FEM CAMPO S.G.T.

Plaxis 3D Foundation: SIMULATION OF MICROPILE TEST WITHOUT TFEG

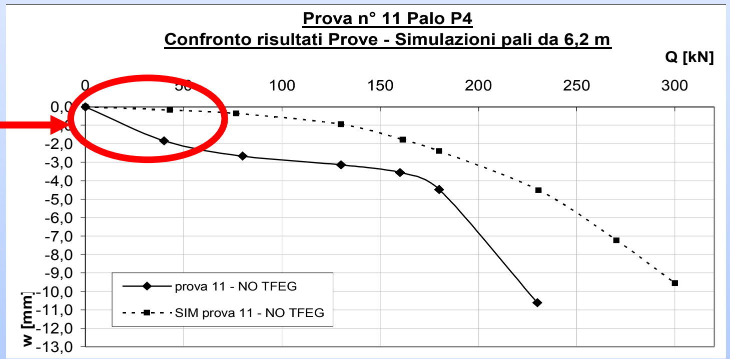
Simulazioni FEM

Mohr Coulomb EPP

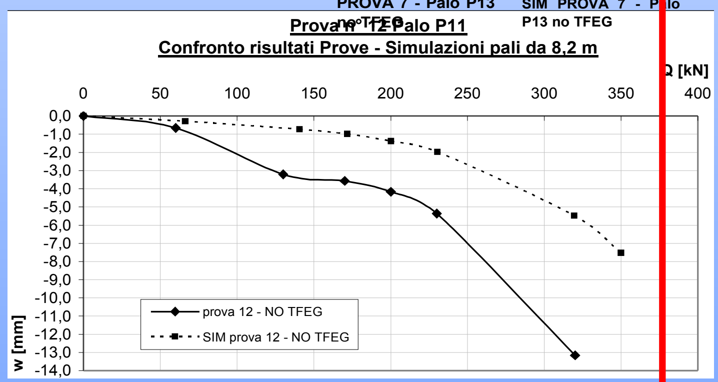
P7 SIM PROVA 3 - Palo P7 no TFEG



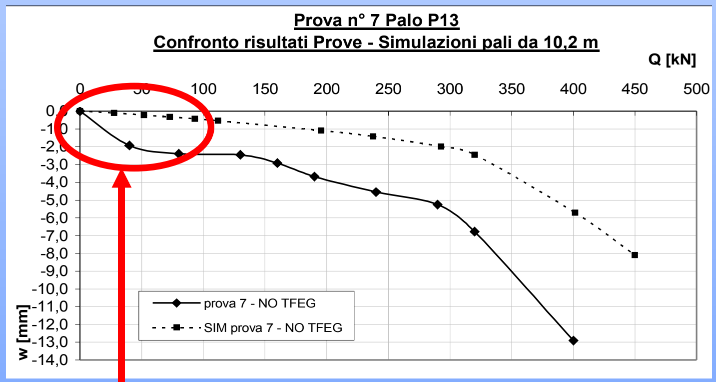
PROVA 11 - Palo P4 no TFEG SIM PROVA N°11 - Palo P4 no TFEG



Palo SIM PROVA 12 - Palo P11 no TFEG



PROVA 7 - Palo P13 no TFEG SIM PROVA 7 - Palo P13 no TFEG



High degree of the slope in the first step loading due to deformation of the measurements devices.

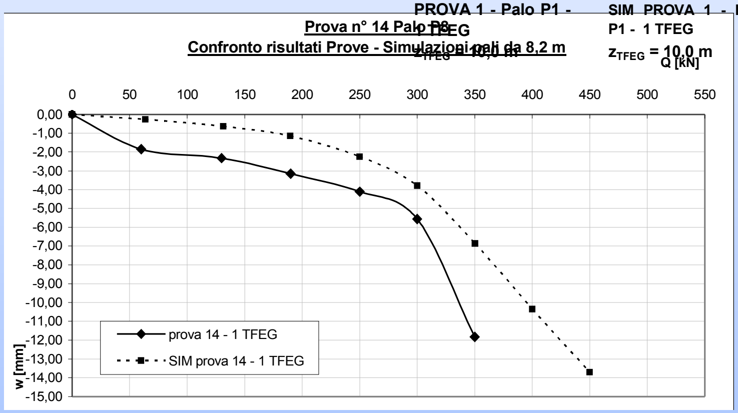
FEM CAMPO S.G.T.

Plaxis 3D Foundation: SIMULATION OF MICROPILE TEST ***WITH TFEG***

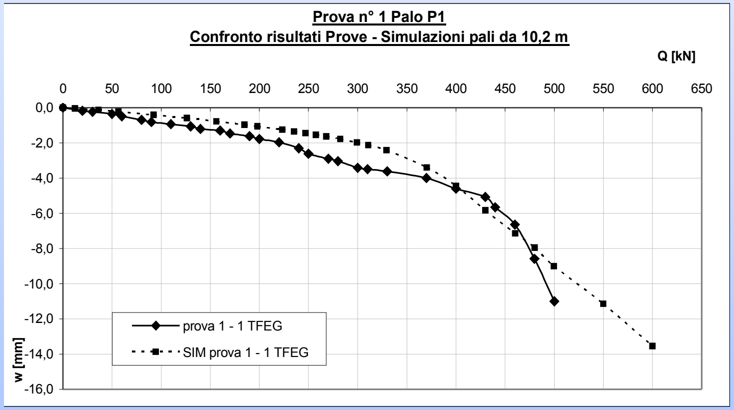
Simulazioni FEM

Mohr Coulomb EPP

SIM PROVA 14 - Palo P8 - 1 TFEG
z_{TFEG} = 8,0 m

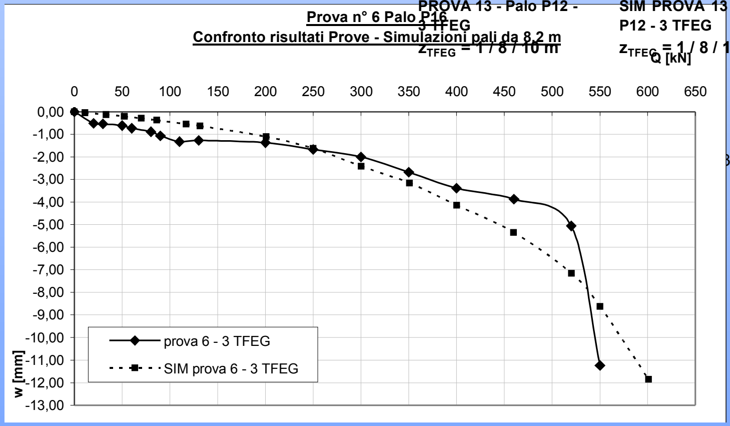


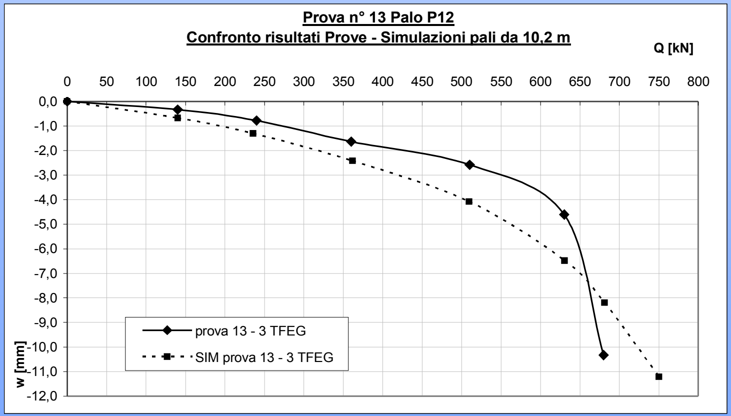
SIM PROVA 1 - Palo P1 - 1 TFEG
z_{TFEG} = 10,0 m
Q [kN]



PROVA 13 - Palo P12 - 3 TFEG

SIM PROVA 13 - Palo P12 - 3 TFEG
z_{TFEG} = 1 / 8 / 10 m
Q [kN]





600,9 -11,86

FEM CAMPO S.G.T.

Plaxis 3D Foundation: DISPLACEMENT FIELD MICROPILE *WITH TFEG*

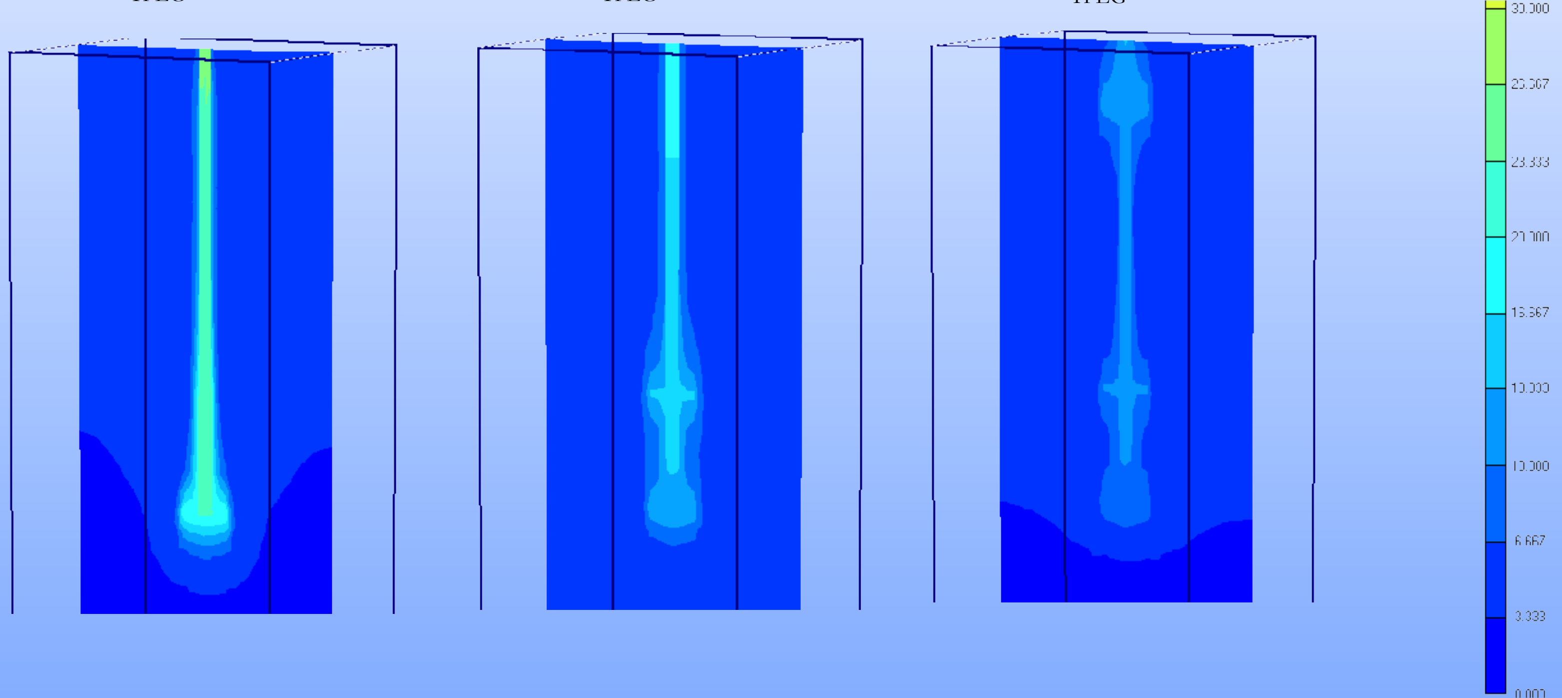
Micropile L=8.2 m

Displacement [mm]

Simulazioni FEM

Mohr Coulomb EPP

z_{TFEG}= 8m | z_{TFEG}= 6-8 m | z_{TFEG}= 1-6-8 m

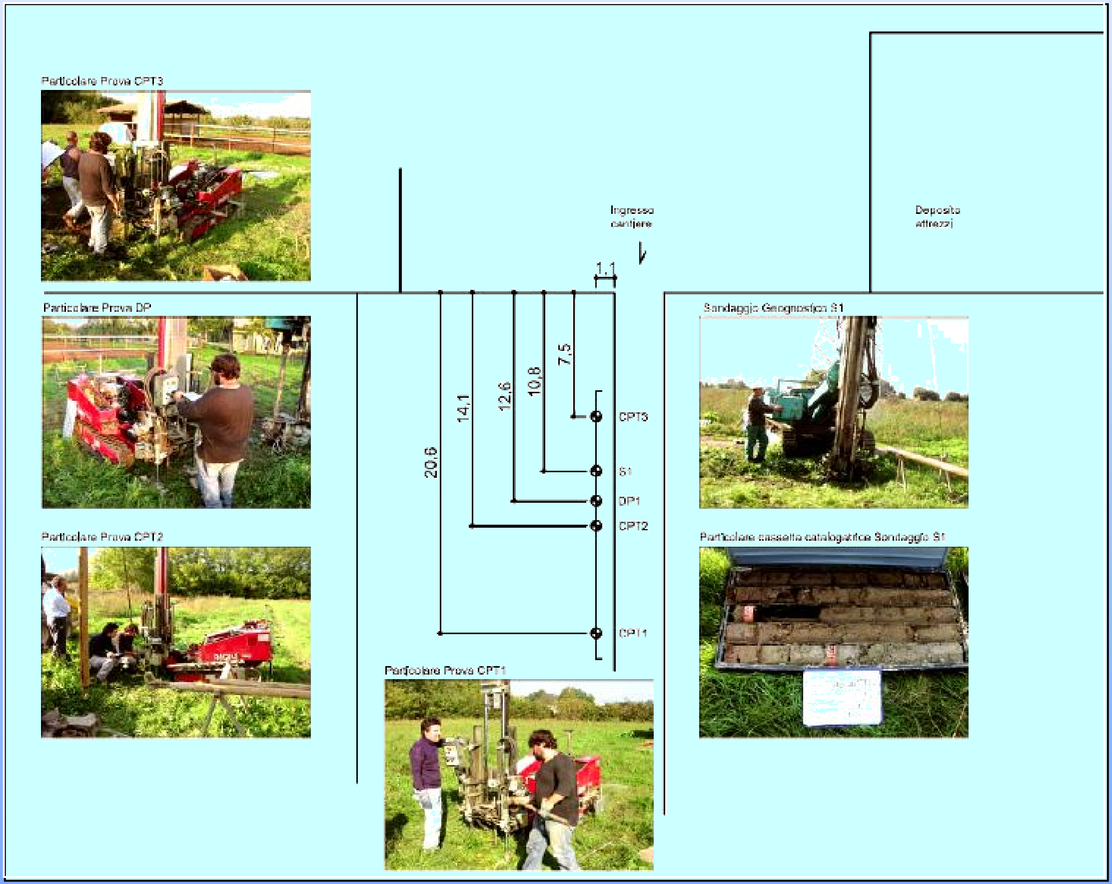


Experimental Field Teano

Experimental field performed in collaboration with **Federico II University** of Naples

- Definition of ***geotechnical model*** with:
  - 3CPT
  - DPSH
  - Core boring

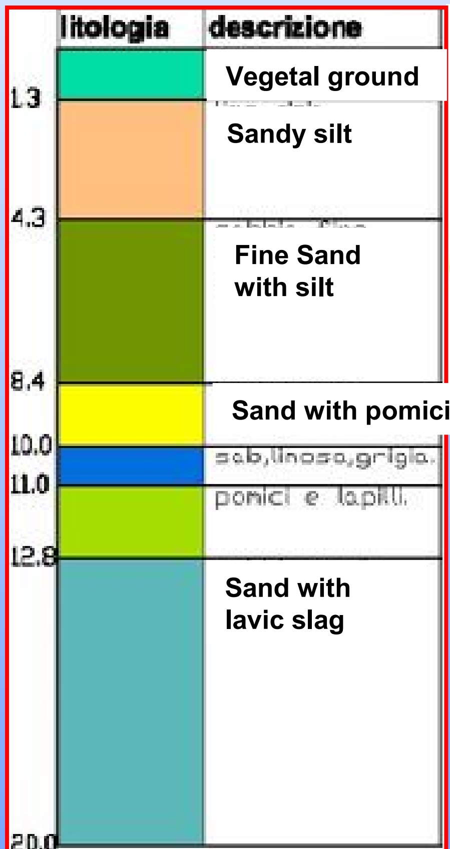
- Definition of the hydraulic condition**:**
  - No water table

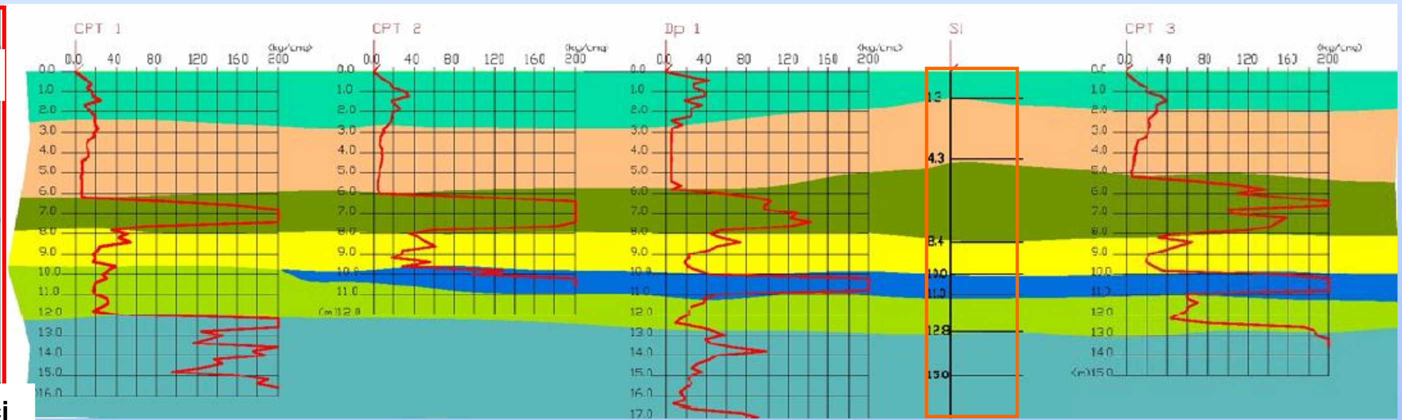


Experimental Field Teano

Geotechnical Model

S1





STRATO		γ [kN/m³]	E' [MPa]	Φ' [°]
1	Limo sabbioso con resti vegetali	16	3	25
2	Limo debolmente sabbioso	16	2	27
3	Sabbia fine con limo	16	28	30
4	Sabbia con pomici	15	8	30
5	Sabbia limosa	19	4	27
6	Pomici e lapilli	11	14	30
7	Sabbia media con pomici e scorie	16	51	35
8	Sabbia media con scorie laviche	16	34	35

Experimental Field Teano

Test pile ubication

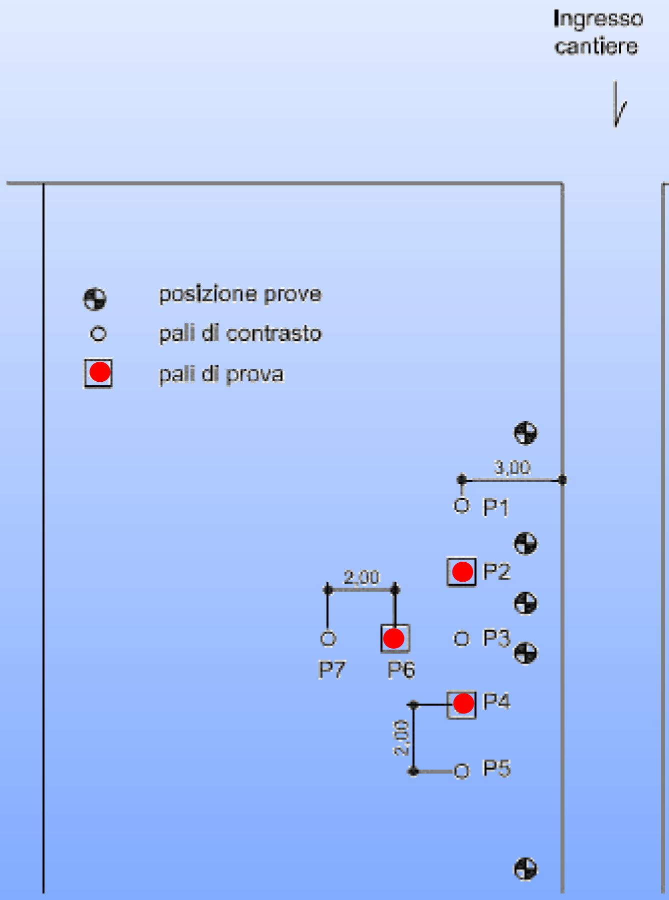
- Pile **P2** build **without TFEG system**
- Palo **P6** build **with TFEG system**

Geometria palo		
Diametro	200	mm
Lunghezza	8	m

Prova N°1
TFEG assente

Prova N°2		
TFEG presente		
Quota TFEG	8	m
Apertura TFEG	80	cm

Strumenti di acquisizione
Strain-Gauges ogni 100 cm
Comparatori centesimali con trasduttori digitali



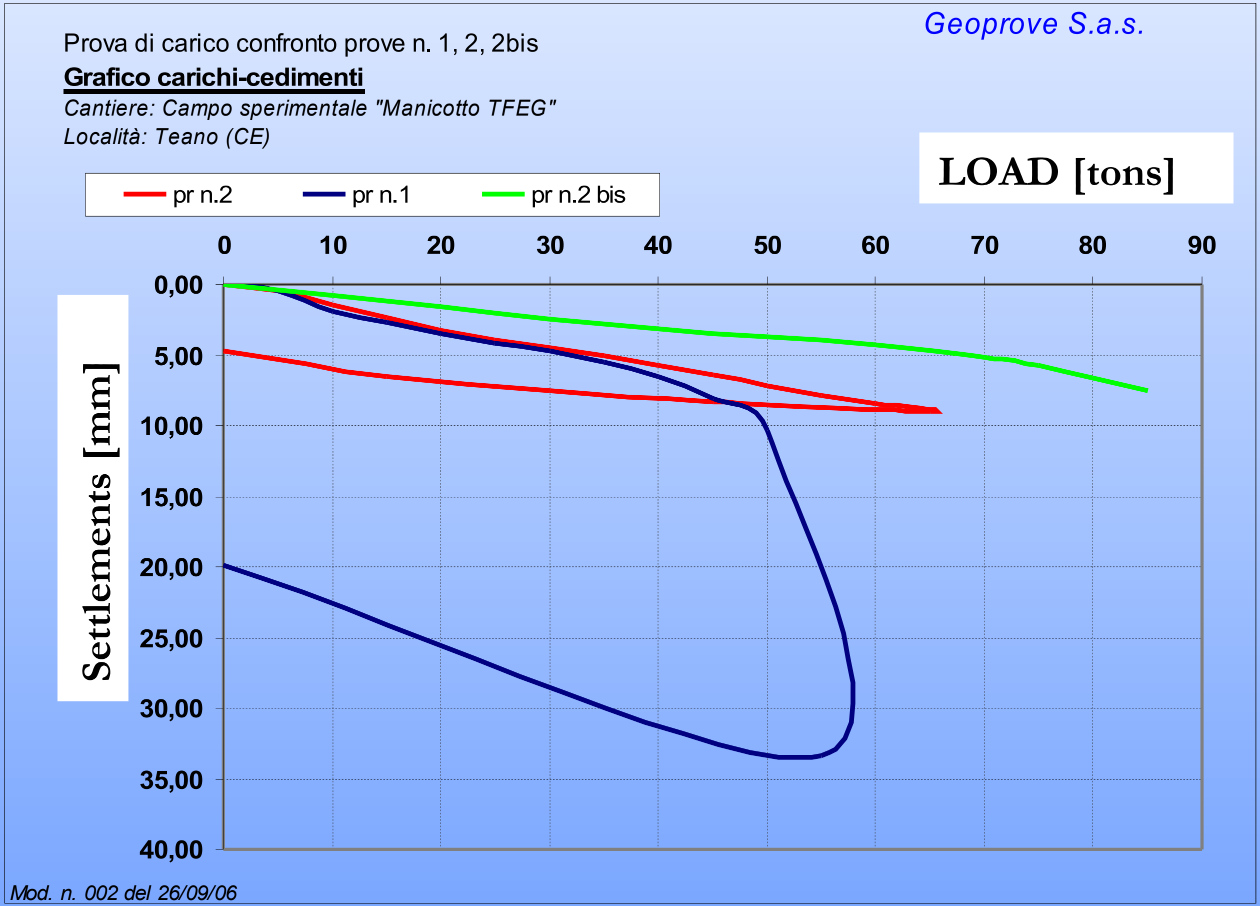
Experimental Field Teano

Load test results

- Pile test n°1 on palo **P2 without TFEG system** (Qlim=50 ton)
- Pile test n°2 on pile **P6** with **TFEG** system

Pile test n°2 is carried out in two phases (load-unload-reload)

Interruption of pile test for failure of tensile pile (Qlim>90 ton)



Practical formulation

Computational model

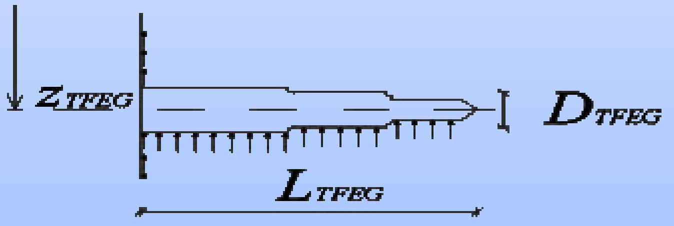
Equivalent shallow foundation

Increase of tip resistance

Practical formulation

Equivalent shallow foundation (FSE)

The increase of the bearing capacity due to the TFEG system can be computed with the classical Brinch – Hansen expression for shallow foundation.



C.D.

$$\Delta P = Q_{lim} = (N_q \sigma'_{vz_{TFEG}} + N_c c' + N_\gamma \gamma D_{TFEG}/2) A_{TFEG}$$

C.U.

$$\Delta P = Q_{lim} = (\sigma_{vz_{TFEG}} + N_c c_u) A_{TFEG}$$

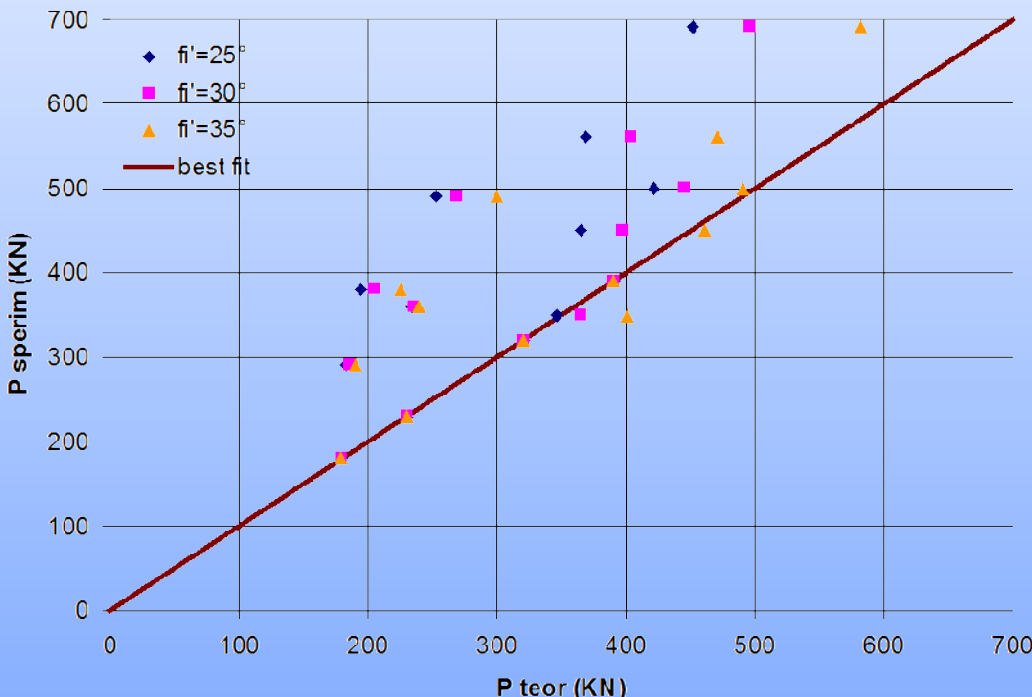
Basic assumption

- *no effect of steel sockets penetration on the surrounding ground*
- *no effect of the deformability of the pile*
- *no effect of the deformability of the sockets*
- *Schematizzaztion of the problem as bidimensional*
- *Failure surface stopping at depth z_{TFEG}*

Practical formulation

Equivalent shallow foundation (FSE)

Experimental vs Theoretical data



Experimental field of San Giovanni a Teduccio (NA)

Simplified stratigraphy:

Unit weight: 16 kN/m³

Friction angel : 25-35°

No coesion

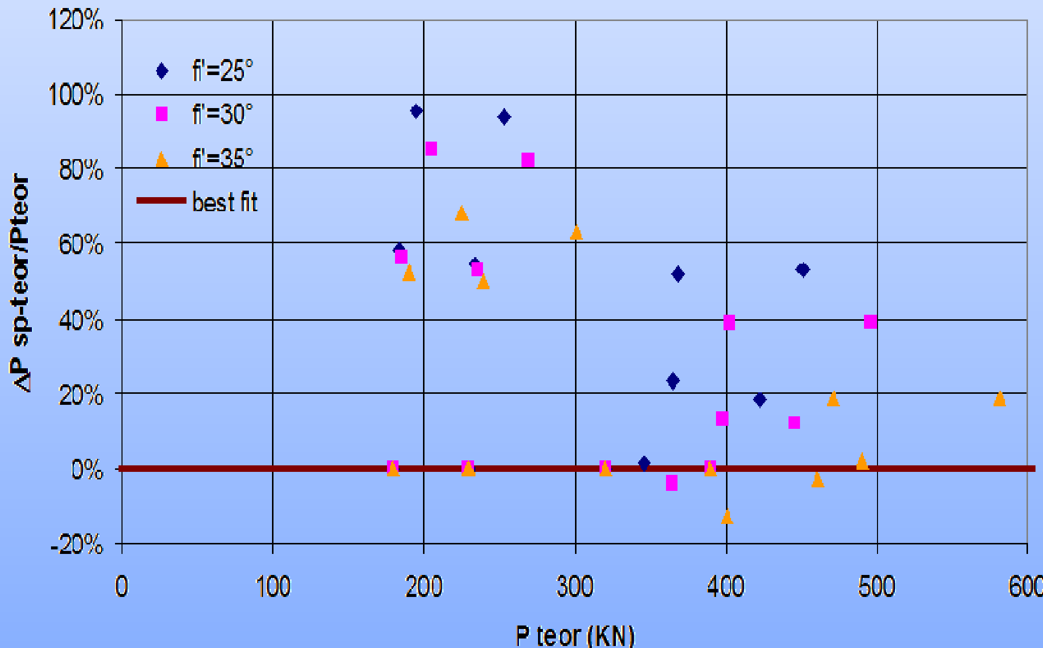
Parametric analysis with friction angle variable (ϕ)

The computed ultimate bearing capacity is lower than the experimenatl value (conservative formulation)

Practical formulation

Equivalent shallow foundation (FSE)

Comparison with previsions



Experimental field of San Giovanni a Teduccio (NA)

Simplified stratigraphy:

Unit weight: 16 kN/m^3

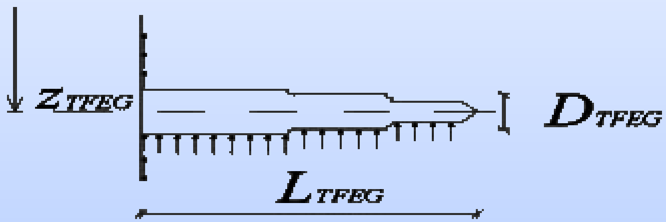
Friction angel : 25-35°

No coesion

The computed bearing capacity with the equivalent shallow foundation understimates the real capacity of the system with error variable between 90% e -15%

Practical formulation

Increase of the tip resistance (IRP)



(Bustamante-Gianeselli, 1982)

$$Q_p = Q_b + Q_l = (q_p \, A_p) + (F_p \, A_l)$$

$$q_p = K_c \, q_{ca}$$

$$F_p = \frac{1}{L} \int_0^L \frac{q_c}{\alpha}$$

It's assumed that:

$$P = Q_{lim} = q_p * A_{sistema}$$

$$A_{sistema} = A_{Palo} + \sum_i D_{TFEG,i} * L_{TFEG,i}$$

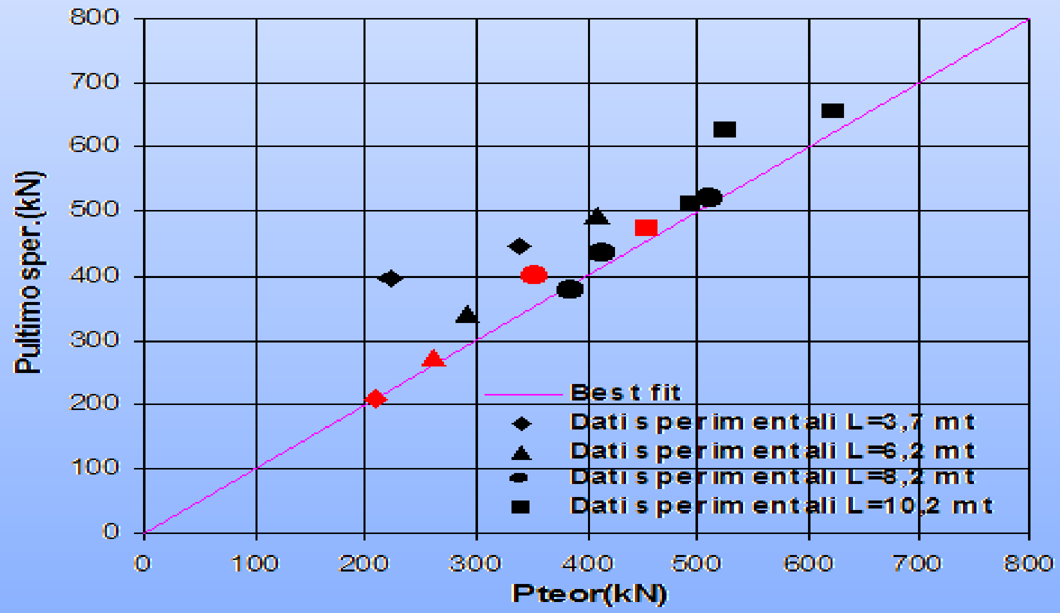
with K_c relative to driven piles

Experimentaly it's been shown that this formulation is conservative.

Practical formulation

Increase of the tip resistance (IRP)

Experimental data correlation

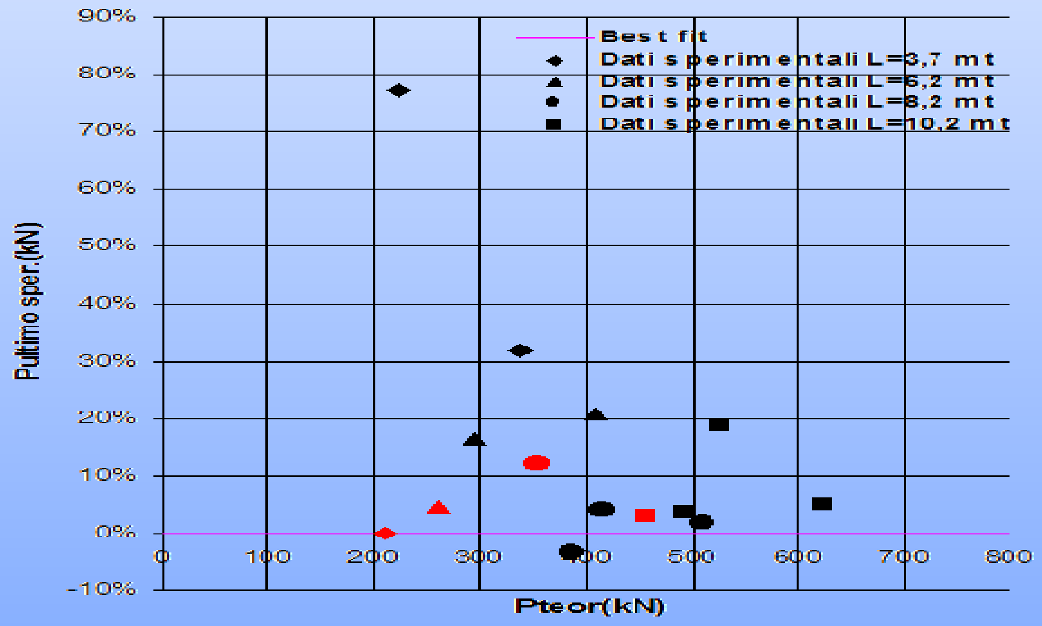


The red symbols indicated the standard micropile that are without TFEG

Practical formulation

Increase of the tip resistance (IRP)

Experimental data correlation



The estimation of the ultimate bearing capacity with B&G formula lead to an understimation of the real bearing capacity of 30% and -5%

This expression (IRP) is validated with other experimental fields.

Thanks for your attention …