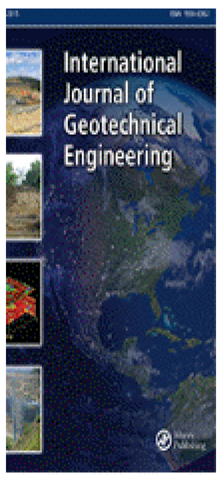

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Field Tests on Screw Micropiles under Axial Loading

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Abstract

Screw micropiles consist of a steel tubular shaft with continuous spiral threads, and a threaded tapered segment at the bottom (Fig.1). They have some notable advantages over conventional micropiles: grouting is not required; they are quick to install and immediately loadable, easy to dismantle and reusable; no earthwork is required prior to installation and damage to the soil is minimal after removal; because the installation equipment is small, they are suitable where the access is limited. Although these piles are potentially useful in many applications as well as being environment-friendly, research on their behavior is limited. The paper presents an ongoing experimental study on the axial response of screw piles. A test site in Cornovecchio (Lodi, Italy) was selected and characterized by means of in situ and laboratory tests. A number of field tests of full-scale micropiles, with diameter varying from 66 to 114 mm and length varying from 0.8 to 1.6 m, were undertaken to investigate the piles' capacity under axial tensile and compressive loads in predominantly cohesive soils.

Fig. 1. View of the test screw micropiles

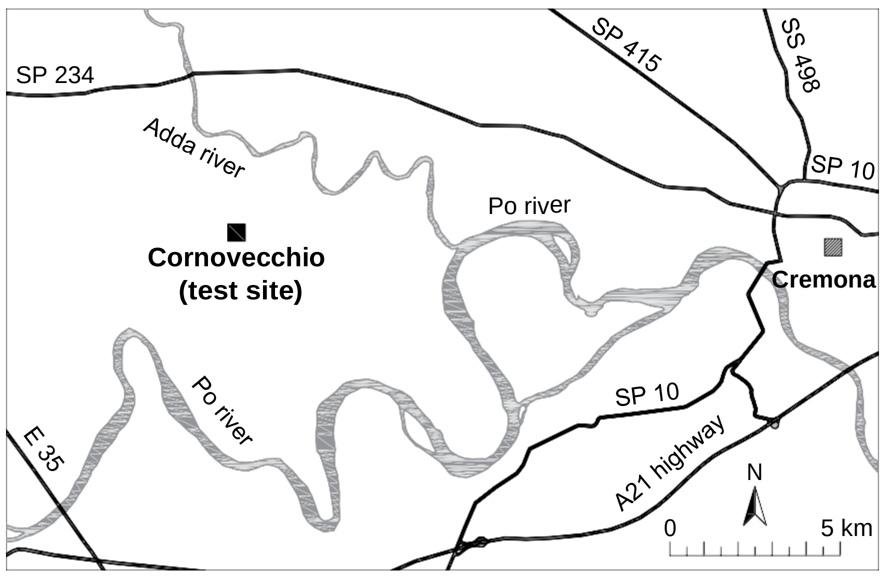

Fig. 3. Map of the test site in Cornovecchio: N 45.142088°, E 9.796147°

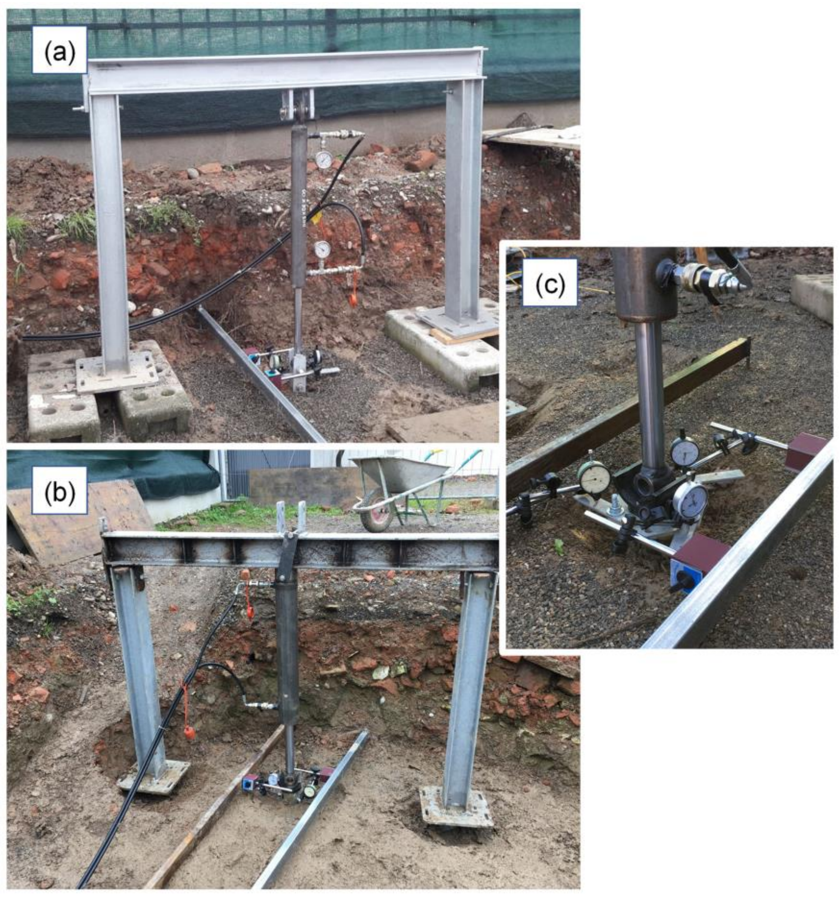

Fig. 5. Configuration of the tensile (a) and compressive (b) load tests, and measurement of pile displacement (c)

Introduction

Screw micropiles in the present research are illustrated in Fig. 1. They are manufactured by Krinner Schraubfundamente GmbH (Germany). The shaft is made of steel coated with galvanization, and the pile is driven into the soil by torsion. The geometrical features of each pile type are summarized in Table 1.

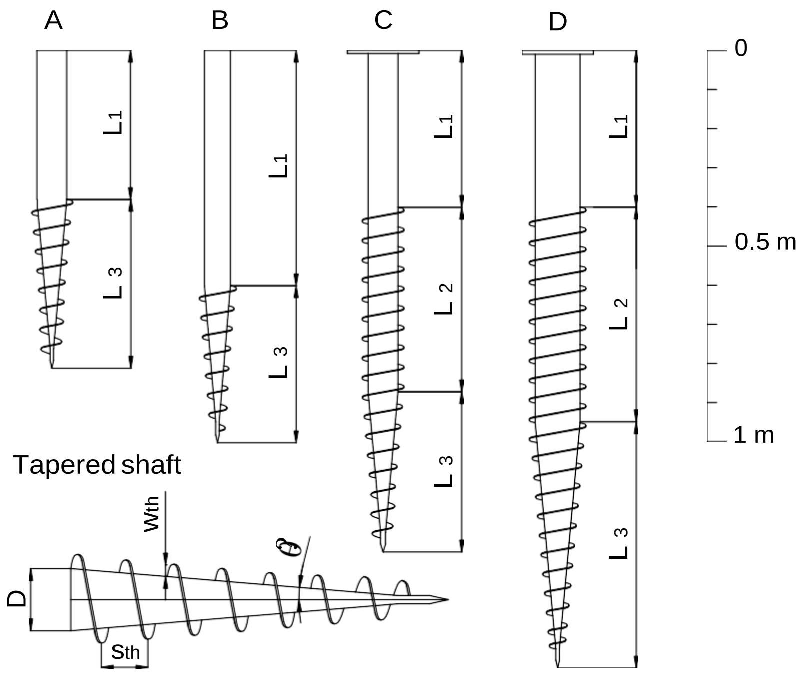

Fig. 2. Schematic of test piles

Pile ID	D (mm)	L (mm)	L_1 (mm)	L_2 (mm)	L_3 (mm)	θ (°)	w_{th} (mm)	s_{th} (mm)
A	76	800	380	n/a	420	5	10	40
B	66	1000	600	n/a	400	5	10	40
C	76	1300	400	470	430	5	15	50
D	114	1600	400	550	650	5	15	50

Tab. 1. Dimension of screw micropiles used for field tests

Test Site, geotechnical characterization

A test site in Cornovecchio (LO, Italy, Fig.) was selected and characterized by means of two CPTs, two exploratory trenches, Shelby tube sampling, and laboratory tests of intact tube samples (Fig.6). The soil below a 1 m thick layer of fill is predominantly composed of stiff silty clay, with thin layers of silty medium-fine sand (Fig. 4).

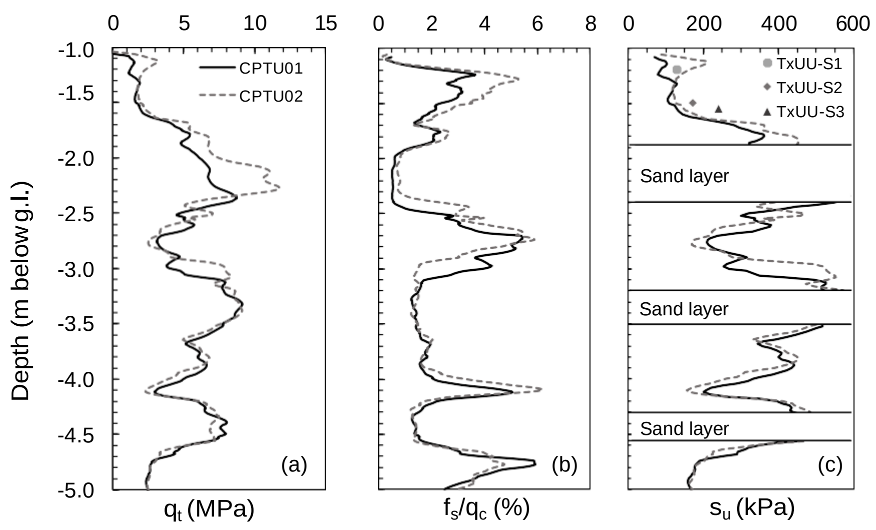

Fig. 4. CPT test results (tip resistance and friction ratio) and undrained shear strength

Test program and procedure

Tests were carried out following the AGI guidelines (1984) (Fig. 5). Twenty field tests were carried out between November 2018 and February 2019; the test program consisted of three tensile and two compressive load tests for each pile type.

The load was applied at increments of 5-15% of the presumed pile capacity or until reaching displacement values of 0.1D.

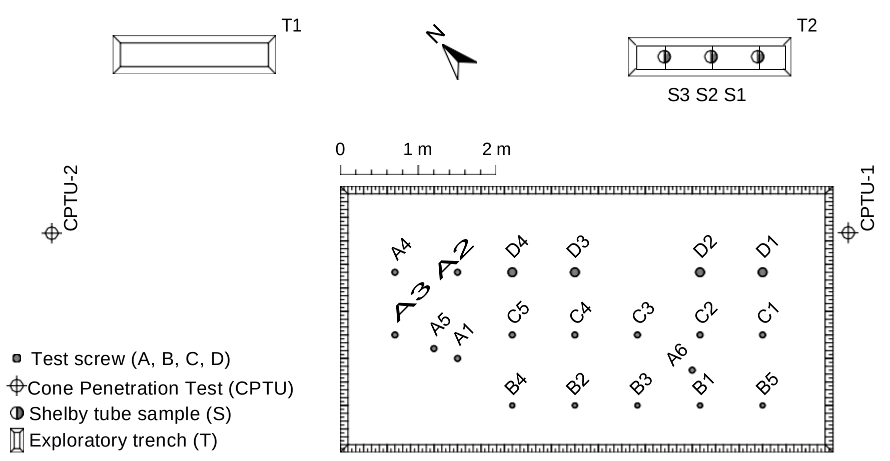

Fig. 6. Layout of the test site including the location of cone penetration tests (CPTU), exploratory tranches (T), Shelby tube sampling (S) and test piles (A, B, C, D)

Test results

Tested micropiles achieved tensile and compressive capacities in the range of 23-60 kN and 20-75 kN respectively, with w/D = 0.04-0.08 (Fig. 7 and Fig. 8).

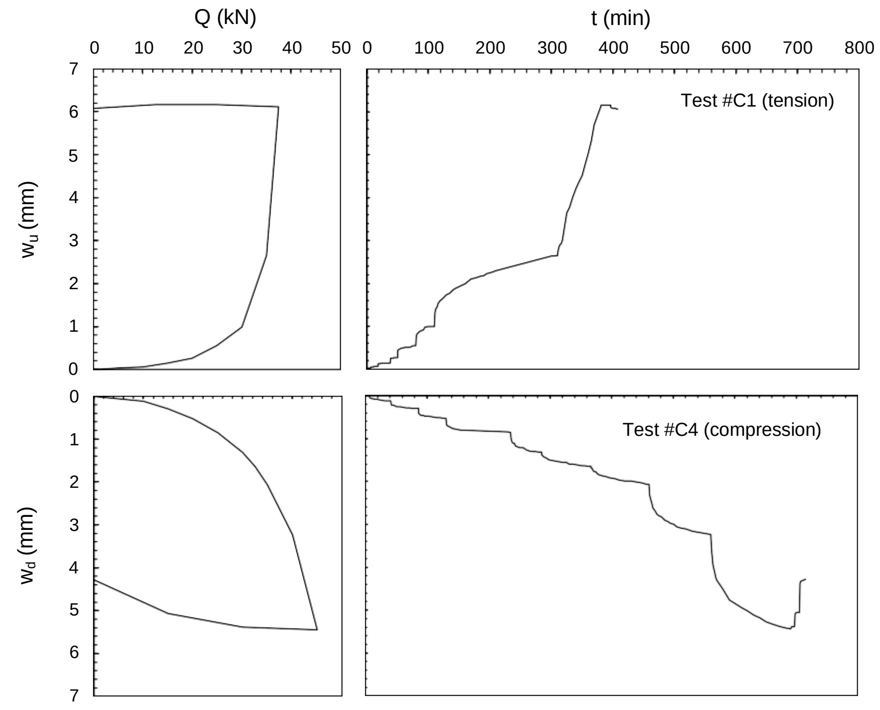

Fig. 7. Typical results of field tests in terms of load-displacement and time-displacement. Comparison between compressive and tensile response of the same pile type (C: L = 1300 mm, D = 76 mm)

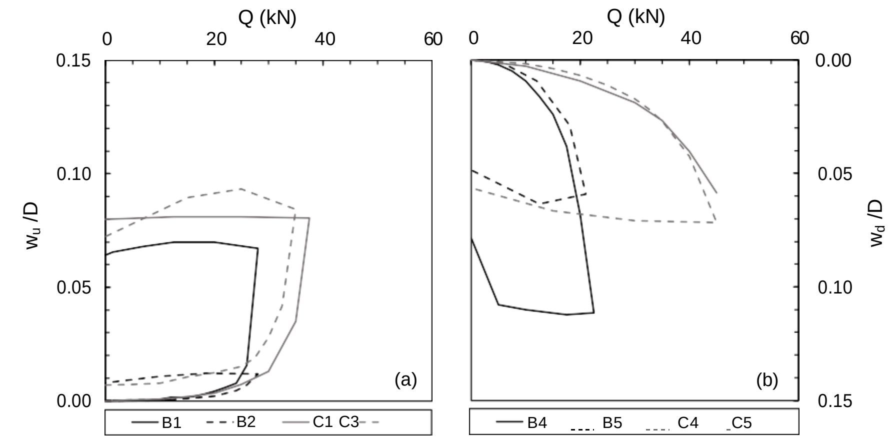

Fig. 8. Selected axial load (Q) versus normalized displacement (w /D) for pull-out tests (a) and compression tests (b)

Axial capacity of screw micropiles

According to Guo and Deng (2018), the capacity of a screw pile at limit state, Q_L, is given by three contributions corresponding to each pile segment: the adhesion along the cylindrical smooth shaft, Q_{sm}; the shear resistance around the threaded cylindrical shaft, Q_{th}; the threaded tapered shaft, evaluated assuming an equivalent cylindrical shaft, Q_{tp_eq}. The three contributions are presented in Eq.1. In this research, the measured values of pull-out capacity were compared with predictions of the analytical method (Fig. 9).

$$Q_L = Q_{CN} + Q_{th} + Q_{tp\_eq} = \alpha s_u \pi D L_{CN} + s_u \pi (D + 2w_{th}) L_{th} + 1.43[s_u \pi (D_{avg} + 2w_{th}) L_{tp}] \quad (1)$$

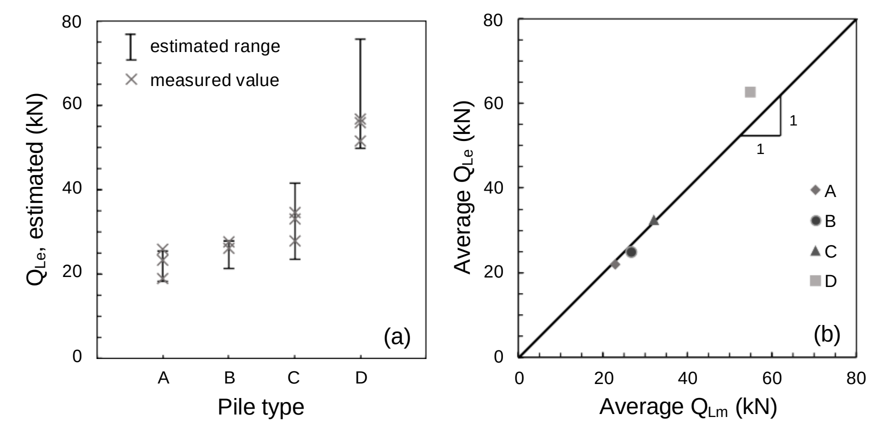

Fig. 9. Limit capacities of selected tests: (a) estimated Q_{Le} versus measured Q_{Lm}; (b) average estimated Q_{Le} versus average measured Q_{Lm}

Conclusions

The following preliminary conclusions can be drawn:

1) In general, test-piles reached the ultimate capacity (either compressive or tensile) for small values of axial movement (1-3 mm), before the ratio w/D reached 0.1.

2) Based on the results of tests, it is safe to say that in cohesive soils the limit state capacity will still be the design governing factor.

3) The comparison between measured and computed values of limit capacity with the method proposed by Guo and Deng (2018) demonstrated the necessity to assume a value of adhesion coefficient α = 0.2-0.4.