GROUNDFIX®

ACTIVE DRIVEN **MICROPILES**

GEOSEC
GROUND ENGINEERING

SPECIALISTS IN CONSOLIDATION

LOW-INVASIVE TECHNOLOGIES

GEOSEC
GROUND ENGINEERING

GROUNDFIX®
Driven micropiles

Generally speaking, driven micropiles (with a shaft diameter or maximum cross-section of the shaft not exceeding 150mm) are used for two purposes: as structural elements and for soil consolidation. They are used as structural elements in the case of new foundations, piles, static improvements of old structures located in seismic zones, and in works for soil reinforcement and containment. In order to consolidate the soil, micropiles are used as elements to reduce settlements in the case of slope stabilization.

GROUNDFIX® from **GEOSEC**® is an active pile technology, which means it is not designed to counteract horizontal movement.

This minimally invasive method, ie. not involving excavation or soil extraction, utilizes special modular steel elements that are connected to each other and driven into the ground under pressure using hydraulic jacks. They can be securely anchored to the original foundation by means of steel clamps and high-strength mortars.

Project methodology

Calculating the micropile's resistance

The inherent resistance of the micropile-ground interface system can be primarily calculated in two ways:

1) By means of methods based on field tests or analytical formulas (long-term and short-term).

2) By means of methods based on load tests until breaking point and methods based on dynamic pile driving tests with electronic control of driving and comparison with load tests.

Both options are included in Table 2.1.
Partial safety factors of the Technical Building Code DB-SE-C Foundations.

Among the main design aspects are:

- Selection of the pile type.
- Analysis of the project loads, in addition to thechoice of calculation method.
- Selection of the number of piles.
- Selection of connections.
- Verification of material durability underoperating conditions.
- Modeling of the foundation-superstructure system.

ICP method developed by Imperial College London

The **GROUNDFIX®** micropile project lends itself to the ICP method developed by Imperial College London. This method is suitable for the following reasons:

1) It has been developed based on load tests conducted on micropiles with a diameter of 100mm, which is very similar to **GROUNDFIX®**.

2) It relies on results, preferably from CPT/CPTU tests or, alternatively, SPT or DPSH tests with shoring. The method proposes a procedure for calculating the skin friction capacity, Qs, and the end bearing capacity, Qp, respectively, for sandy and clayey materials.

The sum of these two components gives the Qlim of the micropile-ground system.

$$Qlim=Qp+Qs$$

Taking into account that it is necessary to distinguish whether the pile has a closed tip, an open tip with plug formation, or an open tip without plug formation

Regulatory and Project Features

GEOSEC® has entrusted ICMQ S.p.A. with the task of carrying out the inspections related to the compliance validation of the **GROUNDFIX®** active micropiling process for soil injection by assembling standard-length steel modules.

The validation led to a **POSITIVE** technical audit in terms of compliance

Technical standard EN 12699:2015

- Execution of special geotechnical works
- Piles executed with ground displacement

(compliant with: EN 12699:2015)

Technical standard EN 1997-1

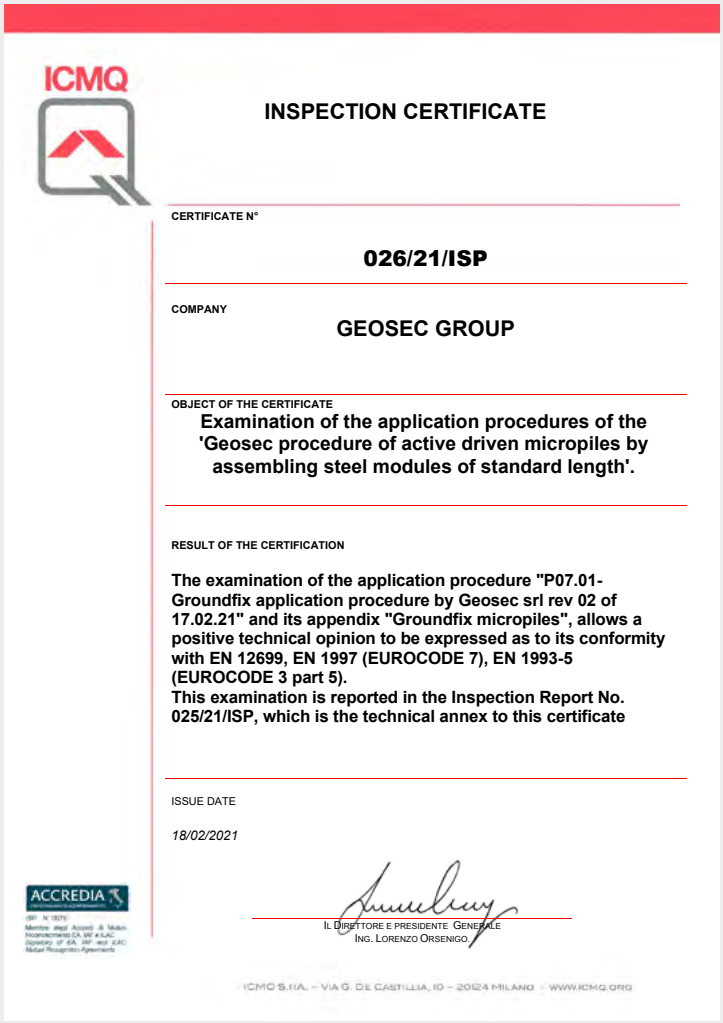
- Geotechnical design
- Part 1: general regulations

(compliant with EN 1997-1:2004/AC:2009)

Technical standard EN 1993-5

- Design of steel structures
- Part 5: Piles and sheet piles

(compliant with EN 1993-5:2007/AC:2009)



ICMQ

INSPECTION CERTIFICATE

CERTIFICATE N°

026/21/ISP

COMPANY

GEOSEC GROUP

OBJECT OF THE CERTIFICATE

Examination of the application procedures of the 'Geosec procedure of active driven micropiles by assembling steel modules of standard length'.

RESULT OF THE CERTIFICATION

The examination of the application procedure "P07.01-Groundfix application procedure by Geosec srl rev 02 of 17.02.21" and its appendix "Groundfix micropiles", allows a positive technical opinion to be expressed as to its conformity with EN 12699, EN 1997 (EUROCODE 7), EN 1993-5 (EUROCODE 3 part 5).
This examination is reported in the Inspection Report No. 025/21/ISP, which is the technical annex to this certificate

ISSUE DATE

18/02/2021

IL DIRETTORE E PRESIDENTE GENERALE
ING. LORENZO ORSENIGO

ACCREDIA

ICMQ S.r.l. – VIA G. DE CASTILLIA, 10 – 20124 MILANO – WWW.ICMQ.ORG

OPERATIONAL PHASES

INSTALLATION OF MICROPILES

GEOSEC
GROUND ENGINEERING

1 Preparatory work

For the execution of micropile insertion, excavations near the existing foundation may need to be carried out in order to ensure the safety of the execution.

2 Installation of steel anchors

Once the existing foundation's integrity and condition have been verified, steel anchors, the size of which has previously been determined, are positioned.

These anchors are necessary for the driving of the micropile as well as the connection to the existing foundation.

The anchors offer resistance against punching and allow for delayed loading through the regulation of the tightening torque in the fastening elements.

3 Driving in the modular elements

Once the jack is positioned, the modular elements that will constitute the micropile foundation are driven in.

Each element is positioned using the thrust of the driving system, controlled by **GEOSEC®** expert technicians.

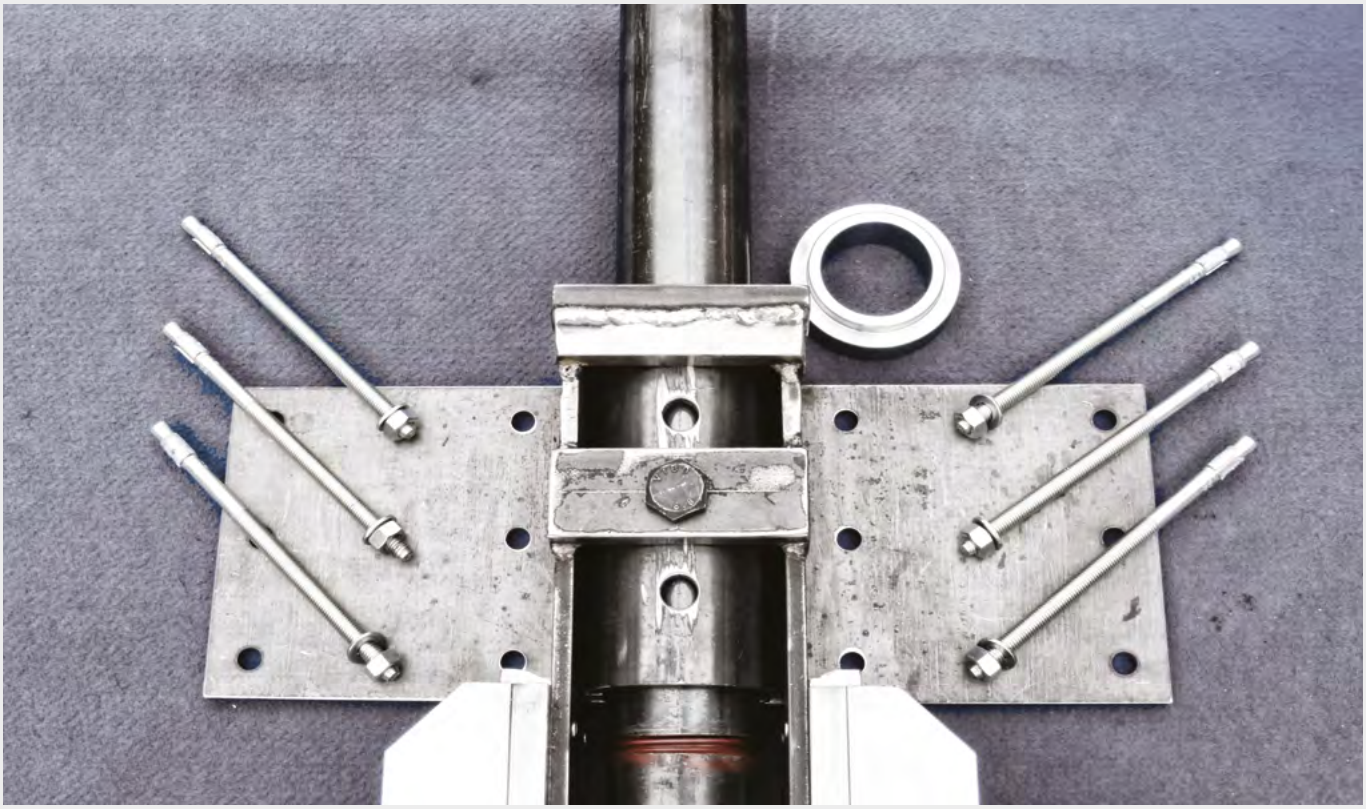
Each module is connected to the previous one forming a single structural element

Thrust is applied slowly, even over multiple piles simultaneously, and lifting of the structure is controlled using a precision laser level.

4 Anchoring the micropile

Once the desired soil depth or refusal has been reached, it is still possible to apply higher than normal loads, with consequent inhibition of primary post-connection subsidence.
Subsequently, the pile is connected to the existing foundation through the anchoring clamp.
Finally, once the last element is anchored, the excess portion of the pile is be cut off.

TECHNICAL SPECIFICATIONS
GROUNDFIX® MICROPILE



The **GROUNDFIX**® driven pile system is based on the use of modular elements made of structural S355J2 steel with a diameter of 63 - 76 - 114mm. The pile driving is carried out using hydraulic jacks attached to the building's foundation through steel clamps. The clamps come in different sizes and geometries, as per the specifications and requirements of the project and the site. There are clamps for vertical, lateral, or reinforced slab anchoring; our carpentry can cater for all project and operational demands.

Tubes and clamps

Steel type S355 for thicknesses t<40mm

- t<40mmfyk [MPa]=355 (Yield strength)
- ftk [MPa]=510 (Tensile strength)

Bolts

The clamps are fixed to the foundation using special elements, up to a maximum of 18 anchoring elements with a diameter of 12mm.

The final anchoring connection between the clamp and the pile is performed using high-strength steel bolts belonging to the following classes:

Splice with front plate

Class 10.9 bolts - Class 10 nuts

- fyb [MPa] = 900 (Yield strength)
- ftb [MPa] = 1000 (Tensile strength)

The threaded cylinders for expansion anchoring are made of galvanized steel with a nut and washer for structural fastening, also used for seismic retrofitting interventions.

- Seismic qualification - Sizes from M12 to M20 are approved for their seismic performance in categories C1 and C2.
- Approved for use in fire-exposed projects up to 120 minutes.
- ETA Option 1 certified - can be used in tension zone (cracked concrete) or compression zone (non-cracked) for special applications in regard to safety.
- Quick driving into the drilled hole with few hammer strikes.
- Quick adjustment of bolt preload.
- Full-length thread along the entire bolt.

Features of the driving system

The pile is driven by a series of hydraulic jacks fixed to the building's foundation by means of steel clamps, which are in turn anchored to the foundation by elements consisting of 18 anchoring bars. The oil return cylinders for thrust and traction can provide a maximum working pressure of up to 700 bar, with a stroke range of 30-260mm and a force ranging from 5 to 30 tons.
The regulation and control of the driving energy is carried out by a small control unit powered by a generator located in the laboratory truck fully loaded with the **GEOSEC®** equipment.

Benefits of our solution

The advantage of using clamps is that they allow for checks of the anchoring system throughout the project phase as well as ensuring the proper sizing of the nuts. The main checks are:

- **Shear strength of the boltening.**
- **Crushing of the connecting clamp.**
- **Design strength of the existing foundation concrete.**

Verification calculation formulas

SHEAR VERIFICATION OF FASTENER BOLTS

To verify the pile fastener bolts, the design load, derived by processing the results of the load test on a pilot micropile, is considered and calculated according to the design approach envisaged in the new NTC 2018. The shear stress is then distributed on the three bolts in such a way that 1/3 of the total force acts on each bolt. The shear strength of the individual grade 10.9 bolt is obtained using the following formula:

$$F_{v,Rd} = \frac{0.5 \bullet A_{res} \bullet f_{tb}}{\gamma_{M2}} \geq F_{v,Ed}$$

In which:

$F_{v,Ed}$= the shear load applied to the shear plane considered

$F_{v,Rd}$= calculation shear resistance of the bolt

A_{res}= resistant area of thethreaded part of the screw

f_{tb}= tensile strength of the bolt material

γ_{M2}= safety coefficient = 1.25

VERIFICATION OF PLATE-MICROPILE CONNECTION BEARING RESISTANCE

Verification of the bearing resistance of the connected elements is performed using the following formula:

$$F_{b,Rd} = \frac{k \bullet \alpha \bullet f_{tk} \bullet d \bullet t}{\gamma_{M2}} \geq F_{v,Ed}$$

In which:

$F_{v,Ed}$ = force exchanged between the connected elements

$F_{b,Rd}$ = bearing resistance calculation of the anchor plate considered

f_{tk} = tensile strength of the plate material

γ_{M2} = safety coefficient = 1.25

t = plate thickness

d = nominal diameter of the bolt

$\alpha = \min\left\{\frac{e_1}{3d_0}; \frac{f_{tb}}{f_{tk}}; 1\right\}$ for edge bolts in the direction of applied load

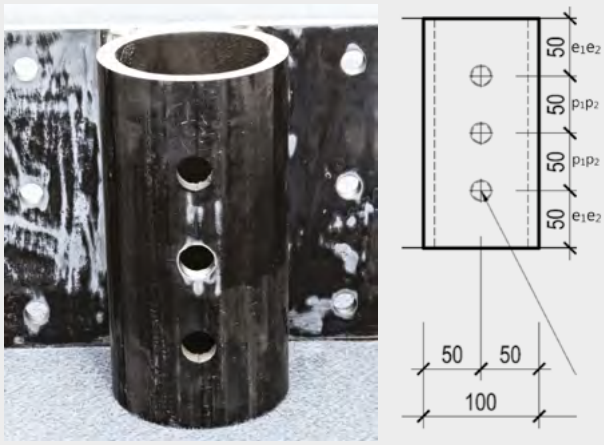
$\alpha = \min\left\{\frac{p_1}{3d_0} - 0.25; \frac{f_{tb}}{f_{tk}}; 1\right\}$ for inner bolts in the direction of applied load

$k = \min\left\{2.8\frac{e_2}{d_0} - 1.7; 2.5\right\}$ for edge bolts in the direction perpendicular to the load

$k = \min\left\{1.4\frac{p_2}{d_0} - 1.7; 2.5\right\}$ for inner bolts in the direction perpendicular to the load

d_0 = nominal diameter of the hole

N.B. : in our case due to the shape of the plate $e_1 \Xi e_2$ and $p_1 \Xi p_2$.



CONCRETE COMPRESSION VERIFICATION

It is also necessary to check that plate-foundation structure anchoring does not cause the concrete of the existing structure to break.

Anchoring is done using eighteen M12 bolts anchored in the concrete to a depth of 20 cm.

Assuming that a force equal to Rd/18 is applied to each bolt and assuming that the bolt transfers the stresses to only half of the lateral surface of the concrete, we will have:

$f_{ed} = T_b/(A_b * L_b * 0{,}5)$

The compression strength of concrete is given by the following formula:

$$f_{cd} = \alpha_{cc} \bullet \frac{f_{ck}}{\gamma_c}$$

In which:

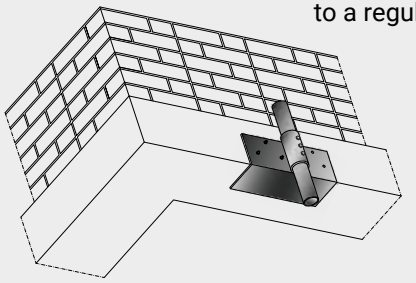
α_{cc} = reduction coefficient for long-lasting strengths = 0.85

γ_c = partial safety coefficient relating to concrete = 1.5

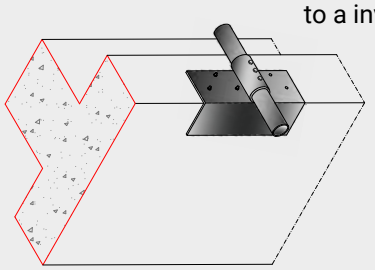
Obviously the verification is satisfied if $f_{cd} > f_{ed}$.

Connection diagrams GROUNDFIX® (76 mm -114 mm) / foundation

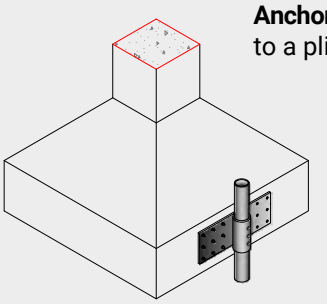
Anchoring L-shaped plate
to a regular foundation



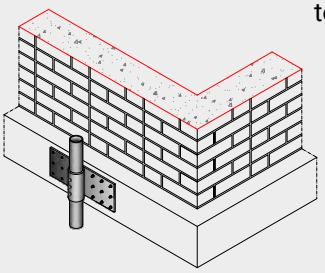
Anchoring L-shaped plate
to a inverte



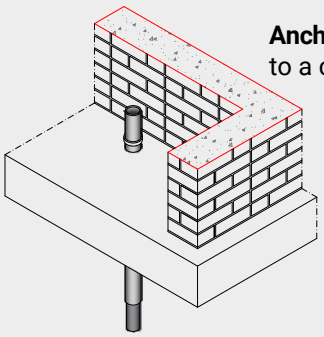
Anchoring a vertical plate
to a plinth foundation



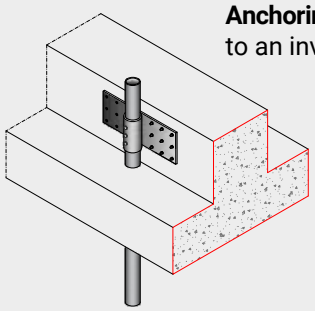
Anchoring a vertical plate
to a regular foundation



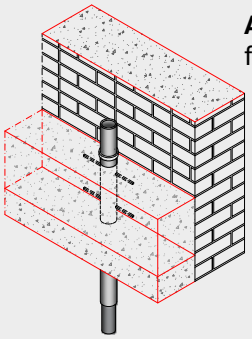
Anchoring of the casing pipe
to a continuous foundation



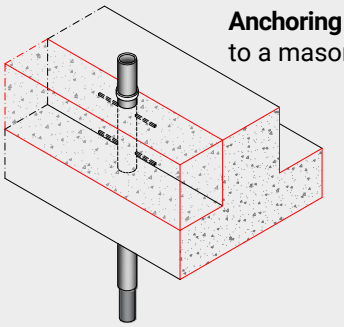
Anchoring of the vertical plate
to an inverted beam foundation



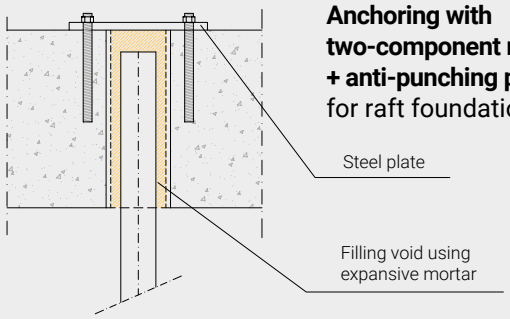
Anchoring sleeve
for brick masonry



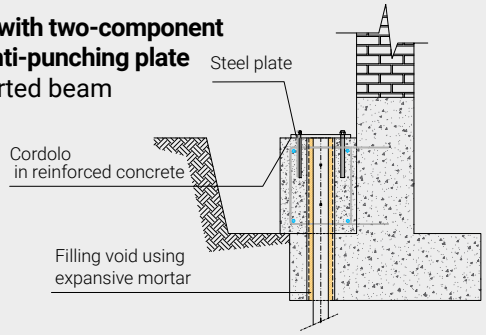
Anchoring of the casing pipe
to a masonry brick wall



Anchoring with two-component mortar + anti-punching plate
for raft foundation



Anchoring with two-component mortar + anti-punching plate
for an inverted beam foundation



CHOOSE THE ORIGINAL

CERTIFIED TECHNICAL SOLUTIONS

Thanks to a set of well-organized technical specifications that meet the standards of reference for the assessment of operational processes to guarantee the highest standards of quality.
ICMQ certification of compliance with standards:
EN12699, EN1997 (EUROCODICE 7), EN1993-5 (EUROCODICE 3 part 5).

PROVEN RELIABILITY AND PROFESSIONALISM

Over 20 years ensuring the safety and stability of your homes.

TECHNICAL BENEFITS

- Possibility to test the load-bearing capacity of every single micropile;
- Possibility of active pre-load;
- No spoil material;
- Quick turnaround times;
- Reduced worksite impact;
- No vibrations generated when driving in the micropiles;
- When allowed for by the structure, subsidence recovery is possible.

GOOD WORKMANSHIP WARRANTY

QUALITY GUARANTEED

GEOSEC® 's solution is unique and holds prestigious technical certificates. It offers a ten-year contractual guarantee with the possibility of extending it to a ten-year warranty, thanks to its cooperation with major international insurance companies.

WANT TO **KNOW** MORE?

FOR MORE INFORMATION, CONTACT US FOR A NO OBLIGATION CONSULTATION.
OUR ENGINEERS ARE AT YOUR SERVICE THROUGHOUT THE UK.

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