MICROPILES

Micropiles offer a cost-effective and efficient means to overcome a variety of foundation construction challenges.

Above: Installation of micropiles for elevated highway with spoil control system.

Center: A compact drill rig is used to install micropiles in a low head-room industrial setting.

Micropiles, also known as minipiles, pin piles, needle piles, or root piles, are small-diameter drilled piles. They offer a viable alternative to conventional piling techniques, particularly in the following conditions:

- restricted access
- low headroom
- challenging subsurface conditions
- environments sensitive to noise or vibration

Micropiles originated in Italy after the second World War to repair damaged structures, and the North American construction industry widely accepted them in the late 1980s. Micropiles are a unique foundation element because of the ability to install them in very limited access conditions and through a wide range of subsurface conditions.

Keller has designed and constructed micropiles for almost two decades. Keller's design, management, and field staff have micropile experience in nearly all geologic conditions and for all types of projects. Applications include underpinning, foundation support, slope stabilization, earth retention, and seismic retrofit. Having the most extensive and diverse fleet of drilling equipment enables Keller to match the equipment with the demands of the project. Whether it's a small single-rig project or one requiring multiple rigs and multiple shifts, Keller can deliver.

Safety is an essential part of all operations at Keller. The micropile installation crew performs daily site hazard analyses on all projects, which highlights hazards as they relate to the specific installation of the piling.

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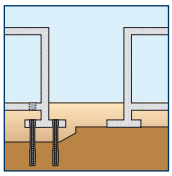
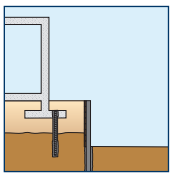
Technology & Applications . . .

Micropiles transfer loads to competent strata to control settlement and provide structural support. Construction is possible at sites with limited headroom or access, settlement or vibration concerns, or sensitive adjacent structures.



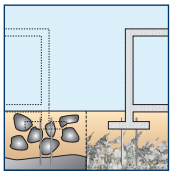
New Loads in Congested Areas

Compact drill rigs make construction in limited headroom or access areas possible, permitting facility upgrades or repairs with minimal disruption to the facility.



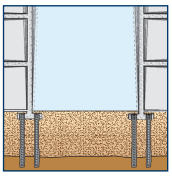
Underpinning/Arresting Structural Settlement

Micropiles can remediate settling foundations or increase the capacity of existing foundations. They can also underpin foundations adjacent to planned excavations to prevent settlement.



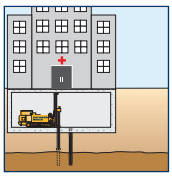
Challenging Ground Conditions

A variety of drilling techniques are available to handle challenging ground conditions such as boulders, karst, and mine geology.



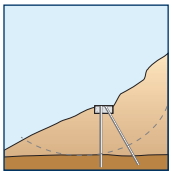
Seismic Retrofit

Existing structures can be retrofitted to meet seismic design requirements. Micropiles can transfer loads through liquefiable soils to competent bearing strata.



Sensitive Areas

Sensitive areas such as hospitals, aquariums, and schools benefit from the low noise and low vibration levels associated with micropile installation.



Slope Stabilization

The Micropile Slide Stabilization System (MS^3) can be used to enhance the stability of slopes.

① *Micropiles being installed to create a reticulated wall for slope stability of railway embankment.*

② *Micropiles being used for pit construction in a manufacturing facility that requires restricted access equipment.*

③ *Exposed micropiles used for underpinning of an existing building which allowed excavation right up to the existing structure.*

④ *Multiple drill rigs installing micropiles on a time-sensitive project.*

⑤ *Micropile installation for a new solar farm.*

⑥ *Connection details for a tension/compression footing for a highly-loaded structure.*

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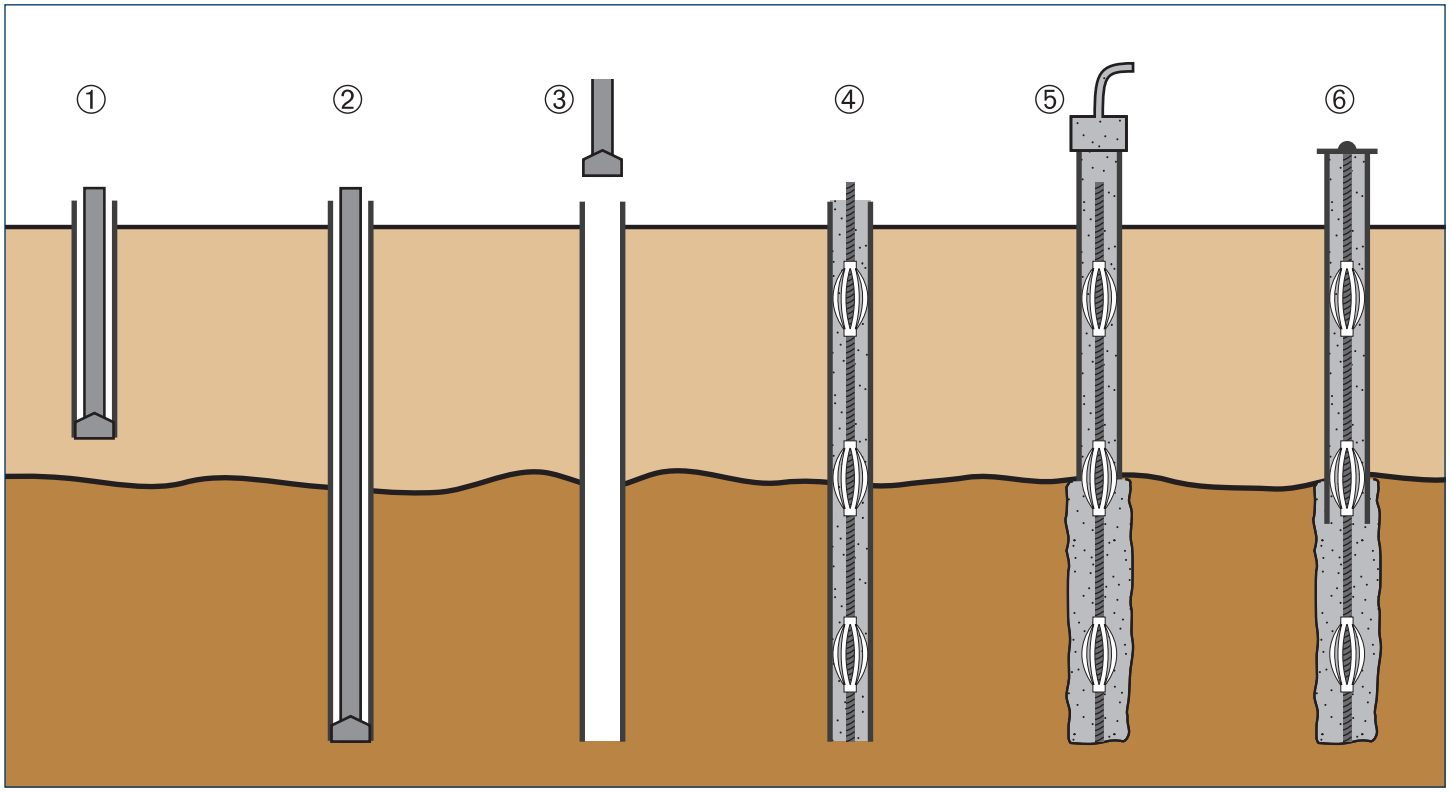
Procedures & Design Considerations . . .

Micropile Procedures

A variety of installation methods and micropile configurations are available to meet the needs of the project. One of the more common installation procedures is illustrated below.

① Begin drilling and/or installation of casing
② Complete drilling to targeted depth
③ Remove inner drill string (if used)
④ Place reinforcement and install grout by tremie method
⑤ Pull casing to top of bond zone and inject additional grout under pressure
⑥ Complete pile



Design Considerations

Available geotechnical information is reviewed and evaluated to determine the correct construction procedures for the micropiles, including the selection of equipment, tooling, grout mix design, and drilling methodology.

Micropiles are suited for any type of ground, with capacities ranging from as little as 222 kN (50 kips) to over 8.90 MN (2,000 kips). Steel reinforcement is used to increase the load capacity and stiffness of the micropile. Design must take into account the loading conditions, the structural capacity, and the geotechnical load capacity of bearing strata.

The required micropile geometry depends primarily on the soil conditions and the applied loads. Since soil properties and structural loads vary from project to project, a range of micropile configuration options is needed. Keller offers the full range of micropile systems and can design and construct the most cost effective solution for any project. Keller also has the capability of combining its micropile technology with one or more of its other specialty geotechnical techniques to meet unique or complex project requirements.

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Equipment & Materials . . .

Micropile designs are tailored to the problems they solve.

Micropile Drill Rig

Keller selects the drilling rig and construction procedure for each micropile project based on site access constraints and the subsurface conditions. In open access sites, larger drills or crane mounted leads can be very productive, reducing cost. Compact rigs allow construction at tight access, low headroom sites. Shortening the drill mast and using threaded drill casing allows micropiles to be installed with less than 2.4 m (8 feet) of headroom. Although the rigs used in these situations are small, the rotary heads are powerful enough to install micropiles into the targeted bearing layer.

Installation of battered micropiles which can take both axial and lateral loading.

Small equipment being used to install micropiles through an existing bridge pier with a detailed spoil recovering system.

Casing installation for a large capacity micropile.

Casing

Micropile casing most commonly consists of mill secondary, API Grade N80 (550 MPa [80 ksi] yield) steel pipe. It is typically flush threaded using specially designed tapered pipe threads. Micropile casing is often used as the drill rod during installation.

Cement Grout

Grouting operations typically use a neat cement grout. In regions with karst or porous formations, low mobility grout can be used to reduce grout loss. Admixtures that control bleed, improve flowability, reduce water content, and retard set may also be used in the grout.

Reinforcement

Reinforcement typically consists of a single steel bar. The bar can vary from 410 MPa (60 ksi) conventional reinforcing bar to 1,030 MPa (150 ksi) high strength thread bar.

The composite structure of a micropile: outside casing, internal grout, and solid all-thread bar used for center reinforcement.

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Quality Control . . .

Load testing verifies that the pile design safely meets the performance requirements.

Pre-Construction

All available geotechnical information and site conditions are reviewed and evaluated to determine the correct design and construction approach for the micropiles, including the selection of equipment, tooling, grout mix design, and drilling method.

During Construction

Daily records maintained for drilling and grouting operations include:

- Pile identification
- Pile location
- Date
- Time of drilling
- Time of grouting
- Soils encountered
- Advancement resistance
- Grout volume
- Grout pressure

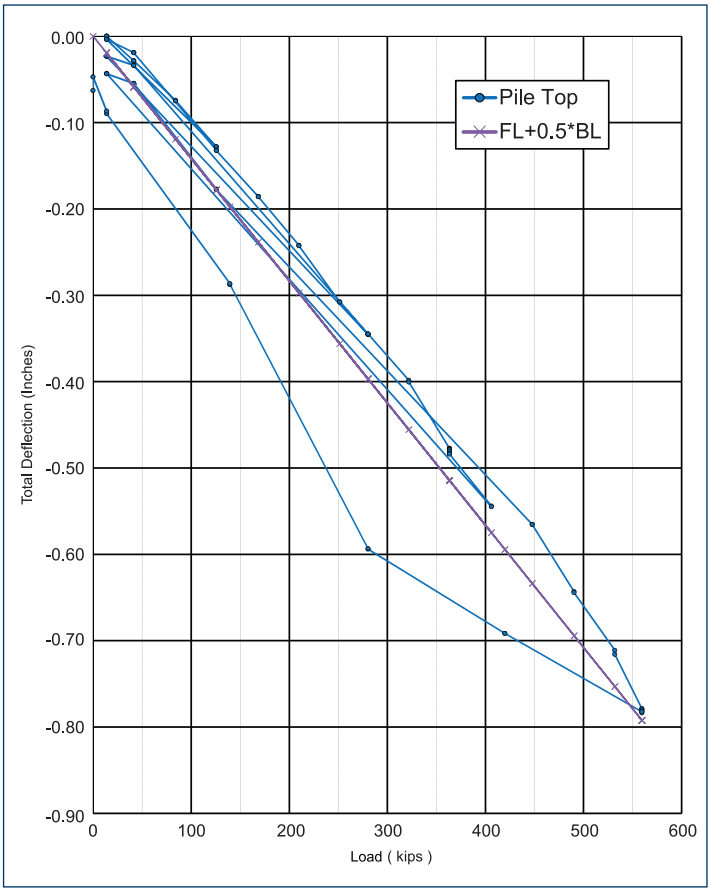
Samples of the grout used to construct the piles are cast into cube or cylinder molds. After curing, they are tested in accordance with applicable ASTM standards to verify that the grout strength meets the required unconfined compressive strength.

A detail QA/QC program is used with all Keller micropile installations. Photo showing mud balance being used to determine the specific gravity of the grout.

Post-Construction

Load testing is performed in general accordance with the appropriate ASTM test procedure. In most cases the quick load procedure is used. The test pile is typically loaded to twice the design load to verify pile capacity. The test pile can be fully instrumented to measure the performance of the pile during testing. Data from strain gauges can be used to determine the load transfer to the soil over the length of the micropile bond zone.

A compression load test being performed to 200% of design load.



Plot of deflection versus applied load for a micropile compression load test.

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Advantages of Keller Micropiles

Micropiles offer a cost-effective and efficient means to controlling settlement and providing structural support or earth retention. Other advantages of using Keller for your micropile needs include:

- *Comprehensive fleet of rigs and tooling for difficult subsurface conditions and limited access*
- *Over 40 techniques enable mid-project modifications to the foundation system if required*
- *Nearly 20 years of experience with a wide variety of applications*
- *Experienced at constructing micropiles for a variety of structures, loads, foundation connections, and subsurface conditions from completing hundreds of micropile projects*
- *Capable of providing value-engineering proposals*

An example of our experience with a wide variety of applications—this remote, restricted access site for transmission lines required helicopters to mobilize equipment and materials.

You have a strong partner with Keller

As a leading specialty geotechnical construction firm, Keller provides a full range of ground engineering techniques and solutions, related to earth retention, foundation support, ground improvement, and ground treatment.

Built on a reputation of safety and quality, Keller sets the standard for performance and innovation through our commitment to the integration, implementation, and further development of advanced technologies for specialized geotechnical construction. With technical excellence, and teamwork at our core, we deliver projects safely, on budget and on schedule.

Offering a wide range of services, including design-build packages, Keller meets the needs of our clients by providing comprehensive cost effective solutions to the most complex problems.

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Design-Build Services for the Complete Range of Geotechnical Technologies

Grouting
Fracture grouting/compensation grouting
High mobility (rock/fissure) grouting
Injection systems
Jet grouting
Low mobility (compaction) grouting
Permeation (chemical) grouting
Polyurethane grouting

Ground Improvement
Cutter soil mixing
Dry soil mixing
Dynamic compaction
Earthquake drains
Rapid impact compaction
Rigid inclusions
TRD - soil mix walls
Vibro compaction
Vibro concrete columns
Vibro (Aggregate) Piers®
Vibro stone columns
Wet soil mixing
Wick drains

Deep Foundations
CFA piles (auger cast)
Displacement CFA piles
Drilled shafts
Driven piles
Franki piles (PIFs)
Helical piles
Jacked piers
Macropiles®
Micropiles

Earth Retention
Anchors
Anchor block slope stabilization
Gabions
Micropile slide stabilization system (MS³)
Sculpted shotcrete
Secant or tangent piles
Sheet piles
Slurry wall - structural or cutoff
Soil nailing
Soldier piles & lagging

Additional Services
Dewatering
Ground freezing
Pit underpinning
Slab jacking

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