

Highway 280 Tidedowns

# Micropiles: Think Small for Big Loads

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**M**icropiles – high-capacity, small-diameter (5 to 12 inches), bored, grouted-in-place piles with steel reinforcement – are steadily establishing themselves as an indispensable option into the standard geotechnical toolbox. First developed in the early 1950s, their use has increased from none whatsoever in 1985 to what is an \$85-million industry in North America today, according to estimates by ADSC: The International Association of Foundation Drilling.

Micropiles are members of the cast-in-place replacement pile family, which includes drilled shafts. With replacement piles, the soil is removed and replaced with concrete or grout and steel.

Conventional drilled shafts resist most, if not all, of the compressive load by the concrete as opposed to the steel. In micropiles, however, high-capacity steel, occupying up to 50 percent of the volume, is the principal load-bearing element. End-bearing is not relied on for structural capacity in most cases.

The micropiles are installed with drilling and grouting methods like those developed for ground anchoring, thereby developing high grout/soil bonding along the micropile shaft. Micropiles work equally well in tension and compression.

## SUITABLE APPLICATIONS

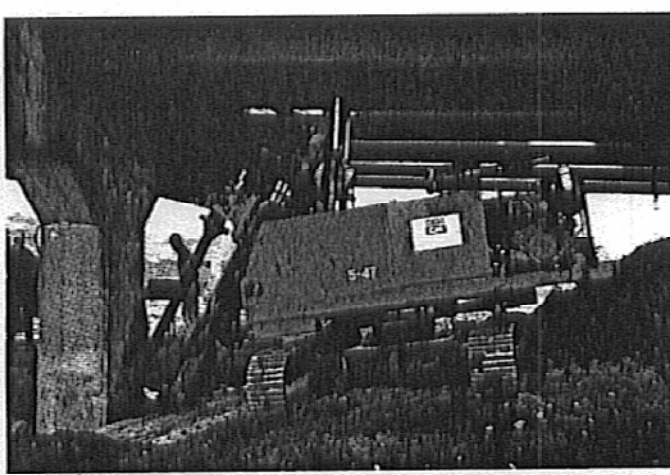
Why go small to carry large loads? First, using specialized drilling equipment, micropiles can be drilled through virtually any ground condition: natural (such as karst, voids, boulders, and cobbles) and artificial (such as existing footings, basement floors, and timber piles).

Micropiles are therefore used widely for underpinning or increasing the capacity of existing foundations because they can be installed directly adjacent to or through the existing structures.

The California Department of Transportation (Caltrans) has seismically retrofitted dozens of bridges in California using micropiles. The micropiles can be drilled through an existing pile cap or footing, and are relied upon to resist both tension and compression forces.

Second, the drilling equipment can be adapted to operate in locations with low headroom or restricted access. Micropiles can thus be installed from within basements or at industrial facilities (refineries, pulp and paper mills) with tight space limitations and sensitive equipment. For example, micropiles, installed from a low-headroom basement, were used as the foundation system for the seismic retrofit of the Old Courthouse Building in San Juan, Puerto Rico.

Third, micropiles can be installed quickly with the least amount of disturbance to existing structures. This makes them ideal for emergency repair, such as was performed at the Mandalay Bay Resort and Casino in Las Vegas to help mitigate unacceptable differential movements. Finally, micropile arrays have been used effectively for slope stabilization.



Low headroom drilling rig installing micro piles for seismic retrofit.

Micropiles are a sophisticated foundation system requiring skilled design and construction. Drilling expertise is often the number one key to a successful project and, conversely, the inability to skillfully drill through all sorts of subsurface conditions will increase the price and owner risk on a project. Additionally, unsuccessful projects will slow the rate of growth of micropile technology.

With the high steel percentage and the specialized grouting equipment needed to build them, a micropile foundation system may be 25 to 50 percent more costly than a conventional drilled shaft foundation. However, in many instances they are the ideal (or only!) solution for challenging geotechnical or physical site conditions.

## MICROPILE CLASSIFICATION SYSTEM

The Federal Highway Administration (FHWA) has developed a classification system for micropiles, categorizing them based on two major criteria: (1) their in situ behavior (i.e., how they transmit loads), and (2) the method of grouting.

Regarding in situ behavior, directly loaded micropiles or micropile groups, in which the micropile itself resists the applied loads, are referred to as Case 1 elements. They comprise virtually all North American applications to date, and at least 90 percent of all known international applications.

An interlocking, three-dimensional network of reticulated piles is referred to as Case 2 elements. Case 2 micropiles are not heavily reinforced because they are not individually and directly loaded; rather, they circumscribe a zone of reinforced, composite, confined material that offers resistance with minimal movement.

Regarding the method of grouting, in Type A grouting, cement grout is placed in the micropile under gravity alone. In Type B, grout is injected into the drill hole under pressure as the temporary steel drill casing or auger is withdrawn. In Type C grouting, grout is placed in the hole as for Type A. Between 15 and 25 minutes later (before the grout has hardened), additional grout is injected via a sleeved grout pipe. The Type D grouting method is similar to Type C, although the first grout is allowed to harden before injecting the second grout. Type C is practiced in France only, but Type D is a common practice throughout the world.

The micropile classifications (Case 1 or 2 and Types A, B, C, or D) are then combined. For example, a repeatedly postgrouted micropile used for direct structural underpinning is referred to as Type 1D.

Case 1 micropiles are typically used for direct structural support, such as that needed for foundations for new structures, underpinning of existing foundations, and seismic retrofitting. Such designs often demand substantial individual pile capacities and so piles of con-

struction types A (in rock or stiff cohesive soil) and B and D (in most soil) are most commonly used.

Case 2 micropile networks are most applicable for in situ soil reinforcement, slope stability improvement, or structural stability applications. Envision the intertwined roots of a tree, which is, indeed how the micropile concept originated by Professor Fernando Lizzi in Italy in 1952.

## CONSTRUCTION TRENDS

Micropile construction has grown increasingly sophisticated since the mid-1980s as the technology has advanced and new equipment and installation techniques have been developed.

The primary enabling technology has been the development of very powerful yet nimble drilling machinery that can maneuver into a variety of workspaces. Drilling manufacturers continue to make progressive improvements to the drilling equipment to coax more torque and pull-back capacity out of the machinery.

Using sophisticated sensors that were traditionally the purview of subsurface investigations, drilling contractors

can now gather real-time data (termed "MWD," or "measurements while drilling") of the subsurface conditions and performing analyses during drilling.

From these data and analyses, contractors are able to refine their drilling technique, and perhaps even refine the original micropile design by optimizing bond lengths. For example, if the subsurface conditions are stiffer or stronger than originally anticipated, the micropiles may be shortened. Conversely, soft soil may require lengthening the micropiles.

Contractors are increasingly using polymer drilling fluid additives and polymer foams to aid in drilling and cleaning. All of these advanced techniques point, again, to the absolute need to use qualified specialty drilling contractors to achieve a high-quality constructed micropile foundation system. ○

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