CHAPTER

13 Micropiles

13-1 Introduction

This chapter provides information on the design applications and construction of micropiles on Caltrans projects.

13-2 Micropiles

The primary reference for this chapter is the technical publication *Micropile Design and Construction Reference Manual*, Publication No. FHWA-NHI-05-039, Federal Highway Administration, U.S. Department of Transportation, December 2005, by Paul J. Sabatini, Burak Tanyu, Tom Armour, Paul Groneck, and James Keeley.

13-2.1 Micropile Definition and Description

A micropile is a small-diameter (typically less than 12 inches), drilled and grouted replacement pile that is typically reinforced. A replacement pile is one that is placed or constructed within a previously drilled borehole, thus replacing the excavated soil. A micropile is constructed by drilling a borehole, placing reinforcement, and grouting the hole. Micropile construction uses similar equipment and techniques as those used for ground anchors and soil nails as described in Chapter 11, *Ground Anchors & Soil Nails*. Many contractors who specialize in drilling and grouting ground anchors and soil nails also construct micropiles. Micropiles are also known as root piles, pin piles, needle piles, and minipiles.

Micropiles can withstand axial compression and tension loads and some lateral loads. Depending upon the design concept employed, micropiles may be a substitute for conventional piles or as one component in a composite soil-pile interaction mass. Micropiles are installed by methods that cause minimal disturbance to adjacent structures, soil, and the environment. They can be installed in access-restrictive environments and in all soil types and ground conditions. Since micropiles provide little lateral resistance, their use on Caltrans projects has been limited to retrofit work and for the construction of retaining and sound walls.

Since the installation procedure causes minimal vibration and noise and can be used in conditions of low headroom, micropiles are often used to underpin existing structures.

Underpinning is the process of strengthening and stabilizing the foundation of an existing structure. It is accomplished by extending the foundation in depth or in breadth so it either rests on a stronger soil stratum, or distributes its load across a greater area. Specialized drilling equipment is often required to install the micropiles from within existing basement facilities or through existing bridge footings.

Most of the applied load on conventional cast-in-place replacement piles is structurally resisted by the reinforced concrete; increased structural capacity is achieved by increased cross-sectional and surface areas. Micropile structural capacities, by comparison, rely on high-capacity steel elements to resist most or the entire applied load. The special drilling and grouting methods used in micropile installation allow for high grout-ground bond values along the grout-ground interface. The grout transfers the load through friction from the reinforcement to the ground in the micropile bond zone in a manner similar to that of ground anchors. Due to the small pile diameter, any end bearing contribution in micropiles is generally neglected. The grout-ground bond strength achieved is influenced primarily by the ground type and grouting method used, i.e., pressure grouting or gravity feed. The role of the drilling method is also influential, although less well quantified.

13-2.2 Applications

Micropiles are most commonly used in two general applications, (1) structural support, where micropiles are loaded directly and where micropile reinforcement resists the majority of the applied load and (2) in-situ reinforcement, where micropile elements circumscribe and internally reinforce the soil to theoretically make a reinforced soil composite that resists applied loads.

Structural Support includes:

- Foundations for new structures.
- Seismic retrofitting.
- Underpinning of existing foundations.

In-situ reinforcement includes:

- Slope stabilization and earth retention.
- Ground strengthening and protection.
- Settlement reduction.
- Structural stability.

Micropiles were originally developed for underpinning existing structures. The underpinning of existing structures may be performed for many purposes:

- To arrest and prevent structural movement.
- To upgrade load-bearing capacity of existing structures.
- To repair or replace deteriorating or inadequate foundations.
- To add scour protection for erosion-sensitive foundations.
- To raise settled foundations to their original elevation.
- To transfer loads to a deeper strata.

13-2.3 Caltrans Applications

AASHTO added a section on micropiles to their design specifications in 2010 (5th edition). But while the rest of the country sees the value, Caltrans limits the use of micropiles due to the lateral demand requirements. The lateral load capacity of micropiles is small because their size is too small to develop any real bending moments. Micropiles can resist lateral load, but not that much. A large quantity of micropiles would be required, too many of them, to resist a significant amount of lateral load.

Caltrans is currently using micropiles for seismic retrofits, earth retention, and foundations for new structures, but mostly retaining and sound walls. Micropiles have also been utilized recently in a Caltrans project for the foundation support of the arch bridge struts for the Spanish Creek Bridge located in Plumas County. (Bridge No. 09-0077, Contract EA 02-373104, 02-Plu-70 KP 56.5/57.2). Refer to Appendix J, *Micropiles,* for a case study.

13-2.4 Seismic Retrofit

Caltrans has used micropiles for seismic retrofitting of existing highway bridge structures. The existing bridge foundations are retrofitted to increase the capacity to resist tension/uplift forces resulting from a seismic event.

A recent Caltrans retrofit project using micropiles was at the Richmond San Rafael Bridge located in the San Francisco Bay Area (Bridge No. 28-0100, Contract EA 04-0438U4, 04-Mrn-580-PM 6.22.) The micropiles were completed in 2005. Refer to Appendix J for a case study.

Micropiles may be economically feasible for bridge foundation retrofits having one or more of the following constraints:

- Restrictions on footing enlargements.
- Vibration and noise restrictions.
- Low headroom clearances.
- Difficult access.
- High axial load demands in both tension and compression.
- Difficult drilling or driving conditions.
- Hazardous soil sites.

Because of their high slenderness ratio (length/diameter), micropiles may not be acceptable for conventional seismic retrofitting applications in areas where liquefaction may occur, given the current standards and assumptions on support required for long slender elements. However, the ground improvement that can be induced by the use of micropiles may ultimately yield an improved earthquake mitigation foundation system.

13-2.5 Earth Retention

The ability of micropiles to be installed on an incline provides designers an option for achieving the required lateral capacity. Near the town of Duncan Mills in Sonoma County

in the San Francisco Bay Area, a micropile retaining wall was constructed in 2007 to stabilize the soil and roadway (Contract No. 04-1S2804, 04-Son-116 PM 3.2.) The wall has two rows of micropiles. The front row was vertical using steel pipe as reinforcement and the interior row was at an angle/incline using 2-#36 epoxy coated bundled rebar. Refer to Appendix J, *Micropiles,* for a case study.

13-2.6 Foundations for New Structures (Retaining Walls)

In 2007, construction started on a retaining wall on Rte 74 in District 12, Orange County (Contract No. 12-043214, 12-Ora-74 PM 13.3/16.6.) Micropiles support the retaining wall, concrete barrier slab, and concrete barrier. Ground anchors are also used to support the retaining wall. Refer to Appendix J, *Micropiles,* for a case study.

Also, on Rte 1, San Mateo County near the city of Pacifica in the San Francisco Bay Area, construction began in 2007 on a retaining wall supported by micropiles (Contract 04-1123U4, 04-SM-1 KP 61.2/64.9). The retaining wall (with barrier and chain link fence) is on a steep cliff facing the Pacific Ocean. A pedestrian sidewalk runs parallel to the barrier and chain link fence. On one portion of the wall, the micropiles are battered in opposite directions providing lateral support. Refer to Appendix J, *Micropiles,* for a case study.

13-2.7 Construction and Contract Administration

The contract specifications[1] describe all submittal requirements and construction requirements for micropiles. Depending on the project location, the micropile design, and the Contractor, different drilling and grouting techniques may be used. The Contractor is required to submit all micropile shop drawings and a step-by-step procedure describing all aspects of micropile installation for authorization.

When required, verification and proof load tests are performed by the contractor. The Department may verify the test loads using a Department-furnished load cell. The Structure Representative will coordinate with the Foundation Testing Branch (FTB) for any Caltrans-required load tests or verification of test loads. The grouting operation can be very messy so the storm water pollution prevention plan (SWPPP) must be enforced and all best management practices (BMPs) implemented.

A *Micropile Construction Checklist* is presented in Appendix K-5 to assist field personnel in preparing documents and inspecting fieldwork to ensure compliance with contract requirements.

13-2.8 Measurement and Payment

The 2010 Standard Specifications handle payment quite differently from the 2006 Standard Specifications. In the 2010 Standard Specifications, the contract item number "sets forth" the governing specification section and all work mentioned in the specification section is included in the contract item. Nothing should be said about the

[1] 2010 SS Section 49-5, *Micropiling,* or Special Provisions for contracts using 2006 SS.

measurement or payment unless there is something that needs further explanation. Detailed payment information is no longer included in the specifications. So, for micropiles, the contract item "Micropile" is measured and paid per micropile (EA). When this contract item is included in the Engineer's estimate for a project, it sets forth the *Standard Specifications*[2]. Any work mentioned in Section 49-5 will be included in the payment for the Micropile contract item, unless otherwise stated in Section 49-5 or in the contract special provisions

No payment will be made for micropiles that are damaged, either during installation, or after the micropiles are complete in place. No payment will be made for additional excavation, backfill, concrete, reinforcement, nor other costs incurred from footing enlargement resulting from replacing rejected micropiles.

13-2.9 Safety

All personnel must wear the proper personal protection equipment (PPE) during drilling and grouting operations to include eye protection, earplugs, and hardhat. Life vests are required when working near water. Safe access must be provided by the Contractor when working on slopes or within trenches. Be cautious and avoid slipping or falling when working near slopes. Caltrans field engineers should not stand too close to the work when the micropile reinforcement and steel pipe is hoisted into place.

[2] 2010 SSP Section 49-5, *Micropiling.*