THE FOUNDATION SUPPORTWORKS NEWSLETTER FOR DESIGN PROFESSIONALS

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Considerations for Solid Square Shaft Helical Piles in Compression Applications

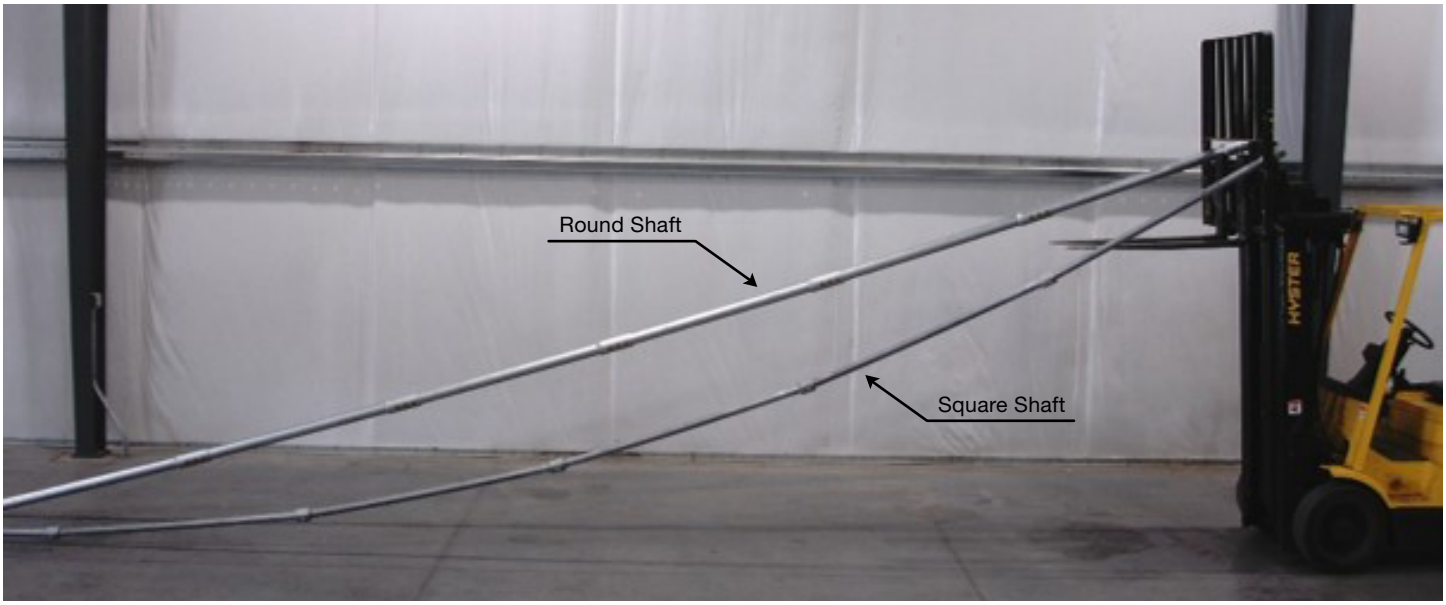

Figure 1

Helical piles quite literally come in different shapes and sizes. The most popular shapes for helical shaft cross-sections are solid square and hollow round. Each provides its own benefits and drawbacks. The more compact shape of a solid square shaft provides superior penetration. The tradeoff is that this comes at the expense of the structural properties of the cross-section. When more steel area is crowded closer to the neutral axis of the pile, it loses stiffness and resistance to buckling. Tension applications do not suffer from the reduced properties because buckling is not a design consideration. For this reason, solid square shaft helical piles are commonly used as anchors in the utility industry for guying towers and poles. They are also the preferred type of shaft in other tension applications, such as for helical tiebacks and helical soil nails.

Several decades ago, some helical manufacturers began promoting the use of solid square shafts in compression applications for both new and retrofit construction. This is unfortunate since square shaft is not well suited for the majority of these applications. This is not only true because of the inherent cross-sectional issues just described, but also the way they are manufactured.

Solid square shaft helical sections are bolted together through a square socket coupling. Although a socket-style connection has advantages, the forging process used to create it has drawbacks. The level of precision that can be achieved is lower than in other types of manufacturing, and this type of coupling connection requires larger gaps and draft angles to be included in its design. This geometry creates a “hinging” effect at each connection, which has a cumulative effect on both straightness and shaft buckling (Figure 1). Once again, these drawbacks apply to compression applications when buckling is a consideration. A more in-depth discussion of round versus square can be found at www.OnStableGround.com within the online FSI Technical Manual.

As part of an in-house testing program, FSI installed and tested two solid square shaft helical piles extending through 43 feet of soft to medium stiff clay for bearing within medium dense to very dense sand. The helix plate configurations were designated appropriately to achieve the maximum torque rating for the 1-½ inch and 1-¾ inch square shafts, 6,500 ft-lb and 10,000 ft-lb, respectively. Five-foot-long extension sections were used to advance each pile to bearing depths of about 53 feet.

Torque-correlated ultimate pile capacities (Q_u) were estimated at 65 kips (1-½ square) and 100 kips (1-¾ square) by multiplying the installation torque by the default torque correlation factor of 10 ft^{-1} for square shafts, as provided by the ICC-ES in Acceptance Criteria 358. However, the compression load versus deflection curves (Figure 2) for the test piles measured much lower ultimate capacities. With piles end-bearing in dense sand, one could interpret the vertical deflections measured at the pile heads as attributed to buckling of the pile shafts.

It should be understood that the slender size of a helical pile is a great benefit during installation since it allows for efficient penetration through the soil. Once loaded, the helical pile relies on the passive resistance of those same soils to provide stability throughout its service life. With hollow round shaft helical piles, experience shows that buckling only becomes a concern within the weakest soil profiles, such as weight-of-hammer material. As this testing illustrates, if solid square shaft is to be used for compression applications, much more consideration must be given to the potential for buckling — even when the surrounding soils are substantially stronger. FSI offers both round and square shaft helical piles. Please contact FSI if you have any questions regarding products or applications.

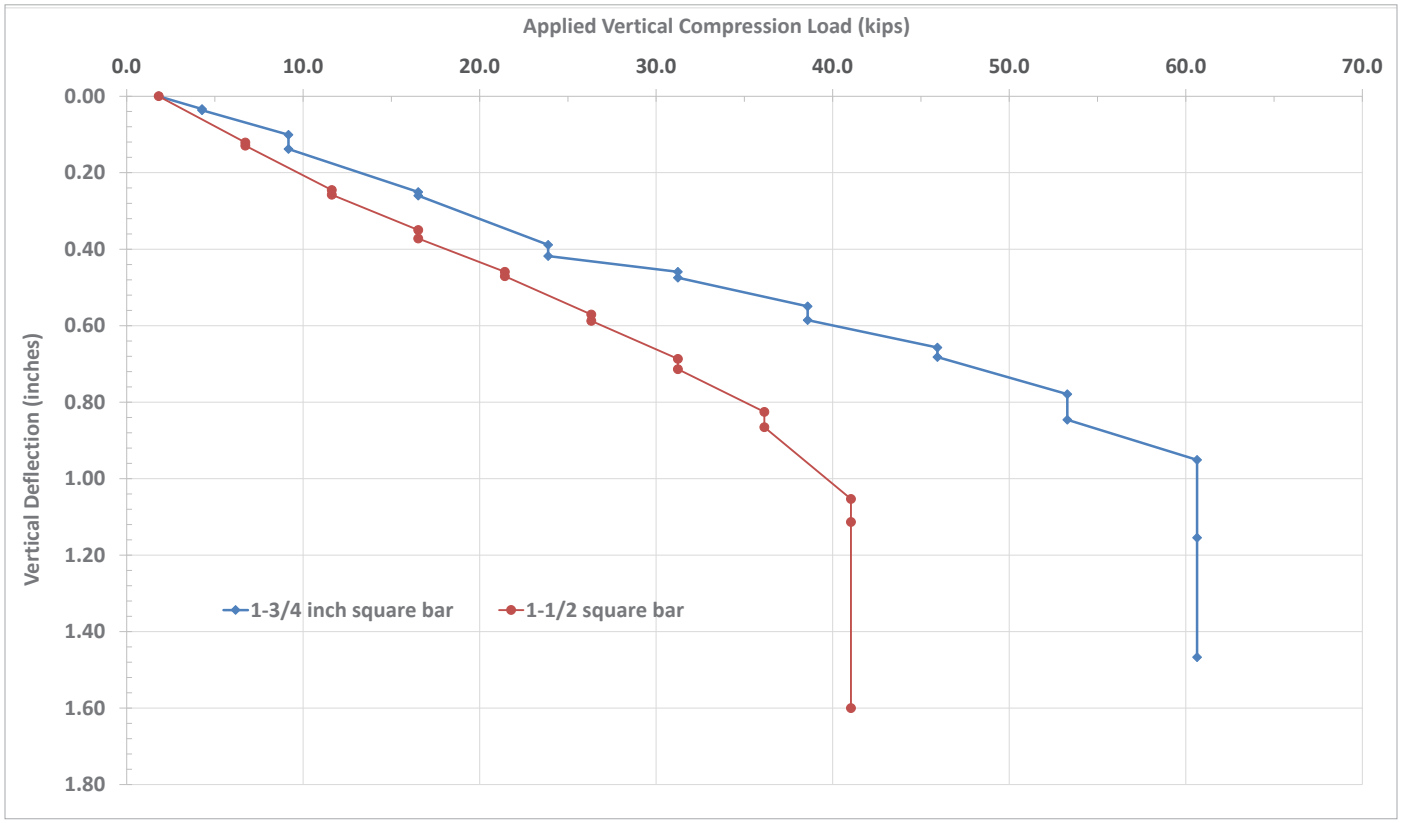

Figure 2

KYLE L. OLSON, P.E. - DIRECTOR OF ENGINEERING

Helical Piles Support Lakeside Retirement Home

Project: **Sanky Residence**
Location: **Pelican Lake, WI**
Pile Installer: **Foundation Supportworks of Wisconsin**

Challenge: The owners eventually planned to build a future retirement home on the property. However, discussions about potential changes to area zoning laws prompted them to start construction immediately. An existing cottage was first removed in order to start construction of the proposed 4,200 square foot home. The soil profile in this area was known to include soils that were dredged from the bay adjacent to the property. Three soil borings were completed to depths of 10, 25 and 34 feet. The geotechnical investigation identified soft clayey silts with trace organics to depths of 21 to 27 feet over medium dense gravelly sand to the bottoms of the borings. Groundwater was encountered at depths of 2 to 3.5 feet. Settlement of the home was a concern given the soft clayey silts and organics in the upper part of the profile.

Solution: The design team recommended helical piles to penetrate the soft silts and organics to bear within the medium dense sand. Helical piles were an ideal deep foundation option for this site given the limited access and the ability to install the piles with smaller equipment, resulting in less anticipated disturbance of the soft surficial soils. The geotechnical engineer contacted Foundation Supportworks® of Wisconsin (FSW) to estimate pile capacities so the structural engineer could develop a pile location plan. Potential pile buckling was considered due to the presence of the soft soils. With buckling considered, the allowable capacities of the Model 288 (2.875-inch OD by 0.276-inch wall) and Model 349 (3.5-inch OD by 0.300-inch wall) round shaft helical piles were limited to 18 kips and 32 kips, respectively, while maintaining a factor of safety of two.

The foundation design included 14 Model 288 and 26 Model 349 helical piles to support the design working loads ranging from 6.7 kips to 32 kips. The Model 288 piles included 10”-12”-14” triple-helix lead sections and the Model 349 piles included 10”-12”-14” triple helix leads followed by a single 14” plate on the first extension. The 40 piles were advanced to depths of 27 to 40 feet below the pre-construction ground surface and to torque-correlated ultimate capacities greater than twice the design working loads. Due to the high groundwater levels, the tops of the piles were set one to two feet below pre-construction ground surface elevations. The 40 piles were installed in less than three days. After the foundation walls were poured, up to 2.5 feet of fill was placed around the footprint of the home to provide frost protection. The design of the home included a crawl space throughout, so no fill was placed inside the foundation walls.

Piles advanced to refusal in the deep gravelly sand

Advancing lead section of 3.5-inch O.D. pile


Piles cut to design elevation and new construction brackets tack-welded in place


Soils on property included dredged material from bay


Completed piles and brackets

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