Weighing in on Concrete Footings

by Glenn Mathewson

In Mike Guertin's recent article "Better Deck Piers" (Feb/Mar 2015), the question is raised about whether or not the mass of the concrete used to build a deep frost-protected deck pier needs to be factored into the deck load calculations used to determine the size of the pier's footing. In that article, the author concludes that the difference between the weight of the soil removed from the footing hole and the weight of the footing and pier is minimal, and that the 10-psf prescriptive dead-load capacity is probably enough to handle the difference. But it's worth looking at this question more closely, because it relates directly to efforts underway to develop prescriptive design methods for typical residential deck footings.

Bearing Area

In the IRC, the foundation sizing guidelines are based solely on bearing area—the horizontal plane at the bottom of a footing that's in contact with and supported by the earth. The goal is to avoid compressing this earth, which IRC prescriptive foundation design achieves by requiring a certain square footage of bearing area based on the magnitude of load and assumed compressive strength of the soil. The earth directly beneath the foundation knows only one thing—the total load it receives. It doesn't differentiate between a large deck with a light, shallow foundation and a small deck with a deep, heavy foundation.

Prescriptive foundation sizing guidelines are based on bearing area and don't account for the weight of the concrete used to form deep footings and piers.

PHOTO: MIKE GUERTIN

Below a concrete pier, undisturbed soil transfers the load in approximately a 45-degree bearing plane. Remove that earth, and now you've got a new joint between two materials. The rigid concrete will not transfer load at the 45-degree bearing plane as the soil previously in its place did. The pier is essentially just an extension that puts the bearing area deeper in the ground and makes the load heavier.

So the short answer is that if you are using the variables provided in the IRC, you do need to consider the weight of the concrete in the footing. It is not assumed in the common 10-psf dead load.

The American Wood Council's DCA6 deck construction guide is based on the IRC and available research. Unfortunately, this means that the weight of the concrete is included in the DCA6 footing-sizing table, too. Developed in a region with no significant frost depth, it assumes shallow footings only and limits their thickness (height). For regions with frost depth, it's assumed that the footing will be completely below grade and the post embedded in the earth.

The problem with that design, of course, is that it inhibits maintenance and replacement and reduces the longevity of the wood post. To extend the footing higher—to resemble what is more commonly called a "pier" in frost regions—you must include the concrete weight in calculations, which in turn increases the required bearing area, which in turn increases concrete weight, and so on, until you end up with a pier diameter so large that it's clearly beyond a reasonable size.

Deep Piers

How is it, then, that 10- to 12-inch-diameter piers 36 to 48 inches deep have historically performed adequately in many regions of the country? Generally, there are two answers: minimal loading and skin friction (also called side shear).

Minimal loading. It's fair to say that most decks never realize the live loading potential of 40 psf; the majority of decks on single-family homes support only the family and a handful of guests. If we assume an average weight of 200 pounds/person (conservatively high), then a deck should be able to support one person for every 5 square feet. That translates to 20 people on a small, 10-by-10-foot deck—standing room only! This is an unusual crowd for a residential deck and I'd stay inside, but it is what we're supposed to be designing for. With that in mind, perhaps many piers *are* undersized.

It's also worth noting that the actual dead load varies considerably from deck to deck. For example, a deck with joists 12 inches on-center will have twice the dead load per square foot as one with joists 24 inches on-center. If that deck also requires deep frost-protected piers, following the 10-psf prescriptive path for dead loads will provide very little reserve bearing capacity to accommodate them.

Skin friction. In engineered systems where a comprehensive soil analysis has been conducted, such as a pier foundation (one much deeper than frost depth) supporting a home, the designer is allowed to consider the bearing resistance due to the friction between the soil around the pier and the sides of the pier. And as anyone who has ever pulled an old pier during a deck rebuild knows, a 36-inch-deep, cast-in-place deck pier also gains some bearing resistance from skin friction, particularly when full-depth forming tubes haven't been used. Breaking it free of the earth takes more force than moving just the weight of the pier, and that resistance works the same for downward pressure. On the other hand, engineered pier foundations for homes often discredit approximately the uppermost 10 feet of soil, which is where a deck pier would be located.

Expansive soil. An issue that complicates the discussion of pier diameter is expansive soil. Along the front range of Colorado, many structures are built on very deep piers to bypass the expansive clays present in upper layers of soil. Large-diameter deck piers that are intended to resist depression due to concrete weight may actually cause the opposite effect and result in a deck heaving upward. In the development of a prescriptive design code, variables in geology, climate, and long-term practices across the entire U.S. must be considered.

The Future of Deep Piers

As efforts continue to provide a prescriptive IRC path for deck design, the industry can expect to hear more about deep frost-protected piers being regulated with bearing area only. This is already the case for the DCA6, the leading deck design guide outside the IRC, and was narrowly avoided during 2015 IRC development—thanks in part to testimony from NADRA. Unless the deck industry invests in research to determine the contribution of deck-pier skin friction in regions with frost depth, builders may soon be directed to dig unusually wide piers, or resort to burying all their posts to a shallow concrete pier hidden at the bottom of the frost depth. At this time, however, I know of none in the works, and I legitimately fear for the future of 12-inch-diameter, 36-inch-deep piers. ❖

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