Frost Heave-Ho

Frost Heave of Deck and Patio Concrete Pier Foundations

Frost heave of foundation systems is a problem that contractors and homeowners encounter in the cold Northern climate on a regular basis. Some of the most common issues usually affect concrete piers supporting decks and/or patios attached to a residence. These isolated foundations react differently to frost than the conventional shallow foundation systems near the exterior walls of heated residences. Most contractors will provide the appropriate diameter pier and depth of footing that is necessary to adequately support the vertical loading required by the Code. There are numerous concrete piers in use right now that have performed adequately without any issues. So, if a contractor has provided a standard of construction that meets the Code, why are there numerous call-backs, warranty claims, and unhappy homeowners because of pier foundations heaving?

If a 30" diameter pier x 8'-0" into the ground still heaves, what can we do?

Inside the Code

Let's look closer at what the Code has to say about frost protection. IBC section *1805.2.1 Depth of footings* indicates that "*foundation walls, piers and other permanent supports of buildings and structures be protected by one or more of the following methods:*

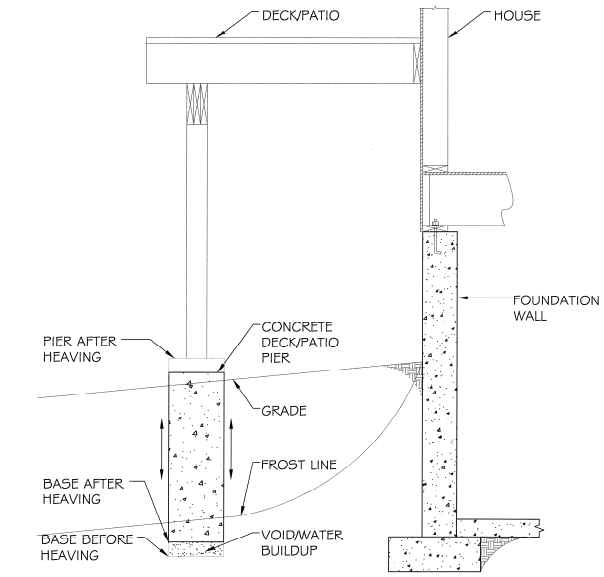
1. *Extend below the frost line of the locality;*
2. *Construction in accordance with ASCE 32; or*
3. *Erecting on solid rock*"

If we carefully examine the language above, we clearly see that the true intent of the Code is to utilize multiple methods to provide frost protection where required. This places more accountability on the contractor to supply a better standard of care. In order to know what methods to use in a given circumstance, we must first understand how frost heave occurs.

The Basis of Frost Heave

Frost results when water in soil freezes and forms ice lenses. These lenses collect water in nearby voids through capillary movement. Water will expand when it takes the form of crystals and ice lenses causing movement of the surrounding soil. The more cycling there is between freezing and thawing of a soil, the greater magnitude of heave displayed by that soil. It has been reported that certain soils can expand up to 10% of their volume. The fundamental concern of frost heave in isolated concrete piers is called **adfreezing**. **Adfreezing** is a condition where the frozen ground surrounding a foundation adheres

to the concrete as the ground heaves upward. **Adfreezing** is usually not uniform from one pier to another and can cause extremely troublesome differential movement. Where and when should we be most concerned that frost heave will occur? To answer this question, let us look at what criteria needs to be met for frost heave to cause problems.



Concrete piers can penetrate below the regional frost line and still be victim to heaving because of ***adfreezing.***

Frost Heave Criteria

Though there is no all-encompassing, inclusive definition of when frost heave will occur; there are some requirements to be aware of. The three fundamental requirements for the formation of ice lenses in soil:

1) Water
2) Freezing temperatures
3) Frost susceptible soils

Identifying and properly dealing with the soil type criteria is the responsibility of the contractor and can result in the difference between a properly functioning pier and one that experiences frost issues. Silty clay soils are the most susceptible to frost heaving because their grain size is most favorable to capillary action of water as discussed above. Capillary action and moisture content cause the most issues in finely grained soils because they are so porous that water flows through it easily. Free draining sands are the least susceptible to frost.

Dealing with Frost Heave-Proactively

There is no exact science to preventing frost heave. The solution requires experienced judgment and a combination of methods. The best prevention is to concisely deal with each of the three criteria discussed above. **1) Water**: If there is no water, ice lenses cannot form. *Usually*, the natural amount of water in a soil is not enough to cause heaving. There typically needs to be an additional source of water to cause problems, i.e. high water table, natural springs, drain tile malfunction, pipe burst, excessive runoff, etc. Reduce the amount of water that the soil sees from roof and surface runoff by utilizing proper surface drainage such as strategic landscaping and gutters. **2) Freezing Temperatures**: In our Northern climate, frost has been reported to extend 6 to 7 feet below the surface. The only way to minimize the effects of the cold

temperatures is to use insulation as outlined in ASCE 32 to reduce the depth of freezing soil. The document is a design guide to alternate methods of frost protection utilizing insulation. Alternative details can be designed by a knowledgeable engineer. **3) Frost Susceptible Soils**: Removal of the frost susceptible soils to the proper depth and backfilling with granular material is very effective with concrete pier foundations. If we remove enough of the poor surrounding soils, adfreezing cannot affect your foundation performance. If these strategies are not all utilized together as a system, frost susceptible soils may heave concrete piers several inches. If the above strategies are not deemed cost effective or practical in any circumstance, then deep foundation systems such as screw anchors, piles, or deep piers should be investigated.

Structural Recommendations

Usually frost heave has little to do with the size of the footing. By installing a larger than normal footing, you create a larger surface area for the ice lenses to grab onto. More effective recommended strategies include **1) Belling** out or oversizing the bottom of the pier to help resist any uplift forces that may occur. When using bells or oversized bases, enough rebar should be hooked into the bottom portion to prevent any concrete breaking or separation. **2) Increasing** the depth of footings below Code required depths are also recommended when using isolated piers. This adds more resistance to uplift for your oversized base. **3) Create** a smooth, slip-surface along the full depth of the footing using sonotube wrapped with a poly material and stapled at the seams.

Do not be a victim of concrete pier foundation warranty claims and unhappy customers by proactively attacking the frost problems during the construction phase. The construction industry has the knowledge and ability to prevent most isolated concrete pier foundation issues by recognizing potential frost criteria (water, freezing, and susceptible soils) and properly dealing with each issue utilizing the strategies described above. Give the old Heave-Ho to frost heave issues!

About The Author:
Nick Hanson, PE, LEED® AP has a bachelor's and master's degree in structural engineering from the University of North Dakota. He is a structural engineer in the Building Services Sector in Minneapolis, MN. He currently provides services to residential, commercial, industrial, and energy projects. He can be contacted at (763)-277-0108 or nick.hanson@ulteig.com.