Deep foundation systems often consist of drilled shafts, driven piles, drilled piles or drilled piers. While the terms pier and pile are often used interchangeably, most accept piles to be defined as smaller diameters while piers are generally 24 inches or larger. Piers are also treated as individual foundations while piles are in groups. Drilled piers have been utilized in foundation construction for quite some time. While the shape and process has changed, the overall theory of piers transmitting the “load of [the] superstructure to lower layers of soil” has not (Das and Sobham 644). Shape types in the past have include belled piers, Chicago, and Gow, while Kelly straight shafted piers, and rock socketed piers are used today. When designing a deep foundation, there are three important factors to consider: cost, productivity, and subsurface conditions.

Focusing on cost is a good starting point in designing a foundation. Drilled piers can be reduced in cost by being shorter, having a smaller diameter, or requiring fewer piers in a system. All of these options require fewer materials while quantity and length of piers require less time. A system with fewer piers could be designed by increasing the length or diameter of the pier. This in turn increases the amount of material used for an individual pier but would possibly reduce the overall amount of materials. Since it has been established that a drilled pier is mainly concrete with a reinforcing steel cage, concrete and steel would be the main materials. Less time refers to both labor and the construction schedule; labor is not a great factor in total cost while the construction schedule is much more vital. Being able to perform under deadlines is more costly especially considering weather and other task related delays. By pooling the expertise of both the structural and geotechnical engineers the overall reduction of costs based on design...
Design of Drilled Piers
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changes in pier diameter and quantity is possible. Occasionally pier length is also considered for redesign to decrease costs.

The productivity of drilled piers is closely related to the cost; higher productivity usually results in a lower cost. A drilled pier system can be simplified to increase productivity. By designing all of the piers to have the same diameter, or in larger projects, limiting to two or three different diameters, allows production to increase. This is because the contractor does not need to switch augers every day or week and they are less limited as which piers can be drilled on a given day. If a pier needs to be cased, there are also fewer diameters of casing required to be readily available to the contractor. Reducing the quantity of piers by increasing the diameter of existing piers also allows for an increase in productivity. As with every structural design, the simpler the drilled pier system, the more likely it will be accurately constructed.

The subsurface conditions will dictate what type of deep foundation system is best structurally in addition to being cost-effective and having good production rates. Some soils require casing the pier, which takes more time and the conditions which require the casing are not ideal for drilled piers. Bearing capacity of the soils is also important to consider. Robert Day declares “the analysis of the load-carrying capacity of piles and piers in cohesive soil is more complex than … cohesionless” (Day 8.20). Foundations in good soils would probably be designed for skin friction as the soil can sufficiently adhere to the concrete while areas with bad soils and shallow rock would have end bearing piers.

Another type of subsurface conditions is the location of groundwater. Just as how footers have to be designed with the water table in mind, piers are also affected by seepage, saturated soils, and uplift. A concern with groundwater is the possibility of rapid drawdown which can
cause unstable slopes and related settlement problems from any de-watering processes, whether
natural or not. Where the water table is likely to intercept the piers, the piers need to be cased to
avoid excess water while the concrete is poured so that the concrete can properly set and cure.

In addition to the three main design factors, group effects are important to consider for
drilled pier systems. Day states “the bearing capacity of pile groups in cohesive soils is normally
less than the sum of individual piles in the group, and this reduction in group capacity must be
considered in the analysis” which he bases on pile spacing and this works in the same way for
piers (Day 8.22). In Principles of Foundation Engineering, Braja Das mentions group effects are
very complex; he explains stresses from piers overlap in the soils between individual piers and
recommends a minimum of 2.5 diameter spacing (Das 397-398). Piers that are closer than Das’
recommended spacing begin to act as a single pier which has limited capacity due to the reduced
amount of bearing material surrounding the individual piers. Lymon Reese discusses the impact
of negative skin friction in pier groups as equaling “70% of the negative skin friction forces on
the individual piers [when conducting] the drained, remolded shear strength” (Reese and Wright
51).

Julie Cromwell, Professional Engineer at THP Limited, thinks the design of drilled piers
is 80% of the geotechnical engineer and 20% of the structural engineer. As a structural engineer,
Mrs. Cromwell designs the reinforcing steel cage, a process which is similar to column design,
generates the concrete mix design, and does load calculations for the building columns which
rest on the piers. George Webb, Professional Engineer at Terracon Consultants, mentioned the
impact of group effects and subsurface conditions. As the geotechnical engineer, Mr. Webb
oversees the geotechnical report, which should be included in the project specifications. He also
recommends minimum length and pier diameters, along with bearing capacity and friction capacity. If the foundation system requires rock sockets, Mr. Webb also recommends the length(s) of the rock sockets.

Occasionally unique field conditions develop that are unforeseen. Mrs. Cromwell recalled a new building which was to be constructed directly next to an existing building. One of the biggest problems she encountered was trying to avoid placing new piers next to existing ones. The placement would require consideration of group effects of the new and existing piers with no absolute certainty of outcome. The alternative was for her to move the piers to locations that would work with the bearing capacity and column loads. The geotechnical engineer would then review bearing capacity as well as boring logs to confirm the new locations. Through partnership of the geotechnical and structural engineers, a drilled pier foundation system can be designed while considering cost, productivity, and the subsurface conditions of the project.

![Figure 1 – Example of a drilled pier (nationaldriller.com)](image-url)
Works Cited

Cromwell, Julie. Phone interview. 20 May 2013.


Webb, George. Personal interview. 7 May 2014.