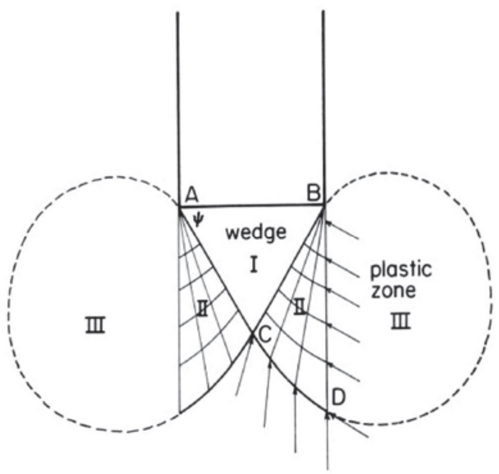
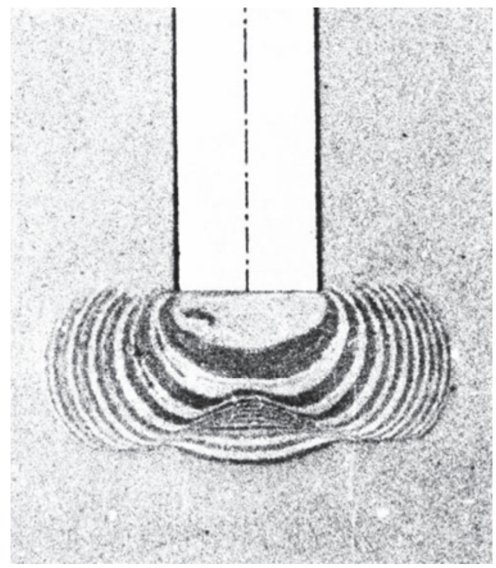
ATLAS RESISTANCE® PIER CAPACITY

Atlas Resistance® Piers develop their capacity primarily through end bearing. The current accepted state of the art practice is for Atlas Resistance® Piers to be installed to a preset performance design criterion. The development of a theoretical capacity model is under study. Current and planned research projects and studies should provide meaningful data for the development of this model in the future.



Assumed Failure Pattern Under Pile Point
Figure 5-1



Failure Pattern Under Pile Point
in Dense Sand
Figure 5-2

In general, the tip of the Atlas Resistance® Pier should be embedded in cohesionless soils with Standard Penetration Test (SPT) "N" values above the 30 to 35 range and in cohesive soils with SPT "N" values above the 35 to 40 range. The Atlas Resistance® Pier will provide foundation underpinning support in end-bearing when positioned into these SPT "N" value ranges based on past installation experience. See *Figures 5-1 and 5-2* for assumed failure patterns under a pile tip in a dense sand.

The Atlas Resistance® Pier is a manufactured, two-stage product designed specifically to produce structural support strength. First, the pier pipe is driven to a firm-bearing stratum then the lift equipment is combined with a manifold system to lift the structure. The Atlas Resistance® Pier System procedure provides measured support strength. Atlas Resistance® Piers are spaced at adequate centers where each pier is driven to a suitable stratum and then tested to a force greater than required to lift the structure. ***This procedure effectively load tests each pier prior to lift and provides a measured Factor of Safety (FS) on each pier at lift.***

Performance Design Criterion

The following guidelines are intended to serve as a basis for the selection and installation of a proper Atlas Resistance® Pier.

- Pier Spacing: The required working load per pier is calculated based on the dead loads and live loads and the ability of the existing foundation to span between the proposed pier locations.

$$P = DL + LL + SL + W \quad \text{(Equation 5-1)}$$

$$P_w = (x) \times (P)$$

where:
P = Line load on footing
P_w = Pier working load
DL = Dead load
LL = Live load
SL = Snow load
W = Soil load
x = Selected pier spacing

- Select Factor of Safety: CHANCE® Civil Construction recommends a minimum Factor of Safety (FS_h) for mechanical strength of the hardware of 2.0.

$$FS_h = 2.0 \text{ (may be varied based on engineering judgment)} \quad \text{(Equation 5-2)}$$

$$R_{w\,ULT} = P_w \times FS_h$$

where: $R_{w\,ULT}$ = Minimum ultimate hardware strength based on structural weight

- Select a Pier System with an adequate minimum ultimate strength rating.

$$R_{h\,ULT} \geq 2 \times Pw \quad \text{(Equation 5-3)}$$

where: $R_{h\,ULT}$ = Minimum ultimate hardware strength based on the published strength rating found in Section 7 of this Technical Design Manual

- Check the maximum pier spacing (x_{MAX}) based upon the selected hardware capacity.

$$x_{MAX} = (R_{h\,ULT}) / (FS_h) \times (P) \text{ (wall and footing must be structurally capable of spanning this distance)} \quad \text{(Equation 5-4)}$$

$$x \leq x_{MAX}$$

- Proof Load: Atlas Resistance® Piers are installed using a two-step process as noted above. First, the Atlas Resistance® Pier is driven to a firm bearing stratum. The resistance force applied during this step is called the Proof Load (R_p). CHANCE® Civil Construction recommends a minimum Factor of Safety[1] (FS_P) of 1.5 at installation unless structural lift occurs first.

$$R_p = (FS_P) \times (P_W) \quad \text{(Equation 5-5)}$$

$$R_p = 1.5 \times (P_W)$$

$$R_{h\,MAX} = (R_{h\,ULT} / FS_h) \times 1.65$$

$$R_{h\,MAX} = (R_{h\,ULT} / 2.0) \times 1.65$$

$$R_p < R_{h\,MAX}$$

where: $R_{h\,MAX}$ = Maximum installation force based on hardware ultimate capacity[2]

[1] Experience has shown that in most cases the footing and stem wall foundation system that will withstand a given long term working load will withstand a pier installation force of up to 1.5 times that long term working load. If footing damage occurs during installation, the free span between piers ($L_{P\ MAX}$) may be excessive.

[2] It is recommended that $\mathbf{R}_{h\ MAX}$ not exceed ($\mathbf{R}_{h\ ULT}$ / 2) x 1.65 during installation without engineering approval.

Additional Notes:

Current practice by CHANCE® Civil Construction is to limit the unsupported pier pipe exposure to a maximum of 2 feet at the published working loads for the standard pier systems. The soil must have a SPT “N” of greater than 4. The pier pipe must be sleeved for pier pipe exposures greater than 2 feet and up to 6 feet and/or through the depths where the SPT value “N” is 4 or less. Sleeve must extend at least 36” beyond the unsupported exposure and/or the area of weak soil. If the anticipated lift is to exceed 4”, then the Atlas Resistance® Continuous Lift Pier System should be used.

Atlas Resistance® Piers can be located as close as 12" (305 mm) between adjacent piers to develop a "cluster" of load bearing elements.

CHANCE® HELICAL ANCHOR/PILE BEARING CAPACITY

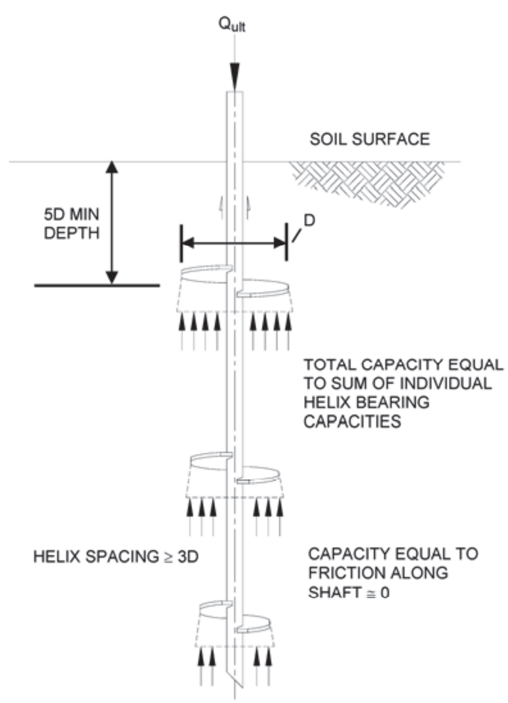


Plate Bearing Capacity Model (Compression)
Figure 5-3

The capacity of a helical anchor/pile is dependent on the strength of the soil, the projected area of the helix plate(s), and the depth of the helix plate(s) below grade. The soil strength can be evaluated by use of various techniques and theories (Clemence, 1985). The projected area is controlled by the size and number of helix plates. For helix depth, two modes of soil failure may occur: shallow and deep failure. The terms “shallow” and “deep” refer to the location of the bearing plate with respect to the earth’s surface. By definition, “shallow” foundations in tension exhibit a brittle failure mode with general eruption of soil all the way to the surface and a sudden drop in load resistance to almost zero. With “deep” foundations in tension, the soil fails progressively, maintaining significant post-ultimate load resistance, and exhibits little or no surface deformation. The dividing line between shallow and deep foundations has been reported by various researchers to be between three and eight times the foundation diameter. CHANCE® Civil Construction uses five diameters (5D) as the break between shallow and deep helical anchors/piles. The 5D depth is the vertical distance from the surface to the top-most helix. Whenever a Chance® Helical Anchor/Pile is considered for a project, it should be applied as a deep foundation for the following reasons:

1. A deep bearing plate provides an increased ultimate capacity in uplift or compression.
2. The failure at ultimate capacity will be progressive with no sudden decrease in load resistance after the ultimate capacity has been achieved.