Drilled shaft foundations, a widely used deep foundation system across North America, are useful in nearly all environments and are capable of carrying high-capacity loads.

Drilled shafts, also known as drilled piers, caissons, bored piles, or cast-in-drilled-hole piles (CIDH), are high-capacity deep foundation systems. A drilled shaft is constructed by drilling a cylindrical borehole to design diameter and depth, lowering reinforcing steel (rebar) into the drilled shaft, and then filling the shaft with concrete. The finished foundation element resists compression, tension, and lateral loads.

Access conditions required for drilled shaft construction are as variable as the diameters and depths to which they can be drilled. Drilled shafts can be constructed in low headroom and limited access and provide effective support for most structures, including buildings, tanks, towers, and bridges. In addition to traditional drilled shafts, Hayward Baker Inc. (HBI) also provides alternative cast-in-place piles, including Continuous Flight Auger or Augercast Piles (CFA or ACIP) and drilled displacement piles (DDP), among others.

HBI has a long history of designing and constructing drilled shafts. HBI owns and maintains a diverse and up-to-date drilled shaft equipment fleet outfitted with the highest quality, state-of-the-art tooling. Experience combined with specialty proprietary drilling equipment and tooling gives HBI the ability to meet specific site constraints such as limited access and low overhead drilled shaft construction. For a variety of subsurface and access conditions, drilled shafts may be the answer for your project.
Drilled shafts provide effective solutions for foundation support when large vertical and lateral load carrying capacities are required. Drilled shafts can be constructed in a range of diameters and access conditions with various reinforcement types, and in nearly all subsurface conditions from soft organics to cobbles and most rock formations. Typical diameters range from 12 to 240 inches and depths exceeding 200 feet have been achieved.

**Building Support**
Drilled shafts are often utilized for the support of new and existing buildings. They transmit large building loads to competent bearing materials at depths.

**Access Shafts**
Access shafts can be constructed of secant drilled shafts arranged in a circular configuration to create a compression shaft.

**Excavation Support**
Walls constructed by aligning adjacent secant or tangent drilled shafts can provide permanent earth retention for excavations.

**Bridge Foundations**
Drilled shafts’ versatility in soil conditions make them useful for bridge abutments and bents/piers with large vertical and lateral loads.

**Limited Access**
Access restrictions, including working inside existing structures or under limited vertical clearance, can be accommodated.

**Transmission Towers**
Transmission towers often have large overturning moments for which drilled shafts are well suited.

1. An expansion to a hospital in California will be built on the drilled shafts being constructed.
2. Drilled shafts constructed in low headroom to support transmission lines in Connecticut.
3. Drilled shafts constructed in limited access will form a foundation for a bridge for the expansion of a roadway in California.
4. Drilled shafts constructed to support a new highway overpass.
5. Construction of a drilled shaft to support a new transmission line tower in California.
Drilled Shaft Procedures

The drilled shaft rig is first placed into position over the drilling location and then the verticality of the drill rig is verified and adjusted as necessary. The drill rig then excavates the material from the cylindrical shaft location to design diameter and depth. Depending on the geotechnical conditions, a variety of methods may be employed to accomplish this. Drilling can be completed with augers, digging buckets, core barrels, down-the-hole hammers, and a variety of other techniques. When caving conditions are present, casing may be utilized or slurry-assisted drilling may be needed to maintain shaft stability. In wet soil environments, excavation can be accomplished by auger drilling and is often assisted by utilizing casing, or slurry to maintain the shaft stability. Regardless of the drilling methodology employed, a similar general sequence is followed.

After the shaft has been drilled to the design depth, the reinforcement is inserted into the shaft. This reinforcement is typically fabricated of rebar, but can be a wide flange or other steel section. Centralizers are located on the outside edge of the reinforcing to ensure sufficient concrete cover. Concrete is then placed into the shaft. If dry and stable geotechnical conditions are encountered during drilling, the concrete may be placed by free-falling it down the center of the shaft, or if conditions or specifications require, by tremie or pump placement from the bottom of the shaft. A tremie typically consists of a steel pipe that extends to near the bottom of the shaft prior to the start of concrete placement. The tremie tip stays embedded in the fresh concrete during placement. After concrete placement, the exposed top of the drilled shaft is finished by either forming the shaft or installing structural embedments into the fresh concrete.

The site exploration defines the site geology, soil gradation, in situ moisture content, soil density, presence (or absence) of groundwater, and rock quality of each stratum within the planned depth. The exploration should extend below the tip of any foundation element so that the soil or rock that will support the planned load can be properly evaluated. In many cases, this requires continuous coring of hard rock at depth to permit visual examination and testing of the rock encountered.

Unconfined comprehensive strength data from the geological exploration is also an essential part in planning the proper methodology to employ in construction. A wide variation of drilling techniques exists for moisture conditions ranging from dry to wet and hardness conditions ranging from soft/loose soil to hard rock.

Design Considerations

Drilled shafts can be constructed in soils ranging from soft organics to dense sand with cobbles to very hard rock. The soil/rock bearing properties at depth, as well as the design load, determine the shaft diameter and the embedment depth.
Drilled Shaft Rigs
As drilled shafts are one of the most widely utilized and versatile foundation types, so is the equipment to construct them. The type of drilled shaft rig is selected for each project based on the geotechnical conditions, site access conditions, and the depth and diameter of the shafts to be constructed. Limited access rigs can be less than five feet wide and weigh approximately 15,000 lbs. while large rigs may weigh 300,000 lbs.

HBI maintains a wide ranging and diverse stock of tools to complete a variety of drilled shaft projects.

The necessary tools on any given project can vary widely from soil augers, rock augers, core barrels, digging buckets, clean out tools, down-the-hole cluster rock hammers, and more. In addition to these, specialty tools are often utilized, including continuous flight augers, long augers for high production, or oscillator drilling.

Reinforcement
Typical reinforcement consists of tied rebar cages. These are most often fully fabricated on the site and placed in a single operation; however, conditions may require cage splicing over the hole.

Reinforcement typically consists of Grade 60 rebar. Bar sizes typically range from #3 to #18 and can be plain or epoxy coated. Reinforcement bars can be single or bundled with splicing either by bar lapping or mechanical couplers. Higher strength reinforcing steel has been utilized to increase the reinforcement efficiency and reduce the number of bars. Adequate clearance between adjacent reinforcing bars is important to maintain proper concrete flow through the cage.

Concrete
Depending on the placement methodology used, the concrete mix ranges from relatively low slump to high slump mixes that are used in wet hole placement conditions or where relatively congested rebar cages are used. When placing concrete in very large shafts, concrete admixtures are often incorporated into the mix to help ensure quality placement throughout the length of the shaft and to control concrete properties including slump and setting time. Admixtures are an integral part in the proper planning and placement of concrete in drilled shaft construction.
Quality Control . . .

Pre-Construction
All available geotechnical information is reviewed and evaluated to determine the correct construction approach for the drilled shafts, including the selection of equipment, tooling, concrete mix design, and drilling methodology.

During Construction
The drilled shaft location, the verticality of the drill rig mast, and the depth of drilling are continuously monitored and verified during drilling.

For dry shafts, the open hole allows for visual observation of the excavation to help ensure that loose material is removed from the shaft bottom. For wet shafts, the bottoms are machine cleaned to minimize loose material.

Material certifications are typically required for reinforcing steel. Concrete is sampled prior to placement to verify that the slump conforms with the specifications and is cast into cylinder molds for unconfined compressive strength testing after curing.

Frequent measurement of the depth to the top of concrete during placement is compared to the theoretical depth based on the volume placed to monitor the relative diameter of the shaft and identify zones of concern. When a tremie is used, the tremie tip elevation is monitored to verify that it stays below the level of concrete in the shaft.

Post-Construction
Non-destructive test methods help determine the quality of the concrete throughout the length of the shafts. Crosshole sonic logging (CSL) and/or Gamma-Gamma logging (GGL) can be conducted by placing test pipes in the shaft reinforcement and subsequently testing the integrity of the pile concrete.

Load testing can be conducted on drilled shaft foundations to verify the load carrying capacity of the foundation elements and/or the quality of the subsurface materials. This testing can be completed on production or sacrificial drilled shafts. Load testing is often completed by one of the following methods: Osterberg Cell (O-Cell), direct static testing, and statnamic testing, for both compressive and lateral testing. Testing is often utilized to refine designs and can result in significant savings to projects by removing some of the uncertainties inherent in the typical foundation design process.

Testing is often utilized to refine designs and can result in significant savings to projects by removing some of the uncertainties inherent in the typical foundation design process.

Osterberg Cell installed in a reinforcing cage for a drilled shaft being constructed in California.

Direct static load testing to verify the load carrying capacity of a sacrificial drilled shaft in California.

Record of the depth to the top of concrete during placement compared to theoretical volume is used to monitor the relative diameter of the 10 foot diameter shaft and identify zones of concern.
Advantages of Hayward Baker Drilled Shafts

Drilled shafts provide economical solutions for foundation support when large vertical and lateral load carrying capacities are required. Advantages of Hayward Baker’s drilled shafts include:

- Variety of equipment and tooling for virtually any condition
- Experienced at both dry and wet shaft construction
- Limited access capability
- Ability to construct drilled shafts in diameters ranging from 12 to 240 inches
- Manufacturing facility to design and build, repair, maintain, and modify equipment and tools needed to complete the work
- Capability of completing alternate foundation systems if required by changed conditions
- Wide variety of applications

You have a strong partner with Hayward Baker

Hayward Baker Inc. (HBI) is North America’s leader in geotechnical construction, offering the full range of pre- and post-construction services for foundation rehabilitation, settlement control, liquefaction mitigation, soil stabilization, groundwater control, slope stability, excavation support, underpinning, and environmental remediation. HBI is annually ranked #1 in the profession by Engineering News-Record (ENR).

Headquartered in Hanover, Maryland, HBI has over 25 offices servicing North and Central America. Since its inception, HBI has established itself in the forefront of geotechnical specialty contracting, evolving and expanding to meet the increasingly complex needs of the construction community. HBI offers full design-build services for any geotechnical construction application.

HBI has the experience and innovation to assist engineers, contractors, and owners with identifying and constructing the most economical solution that satisfies the requirements of each project, typical or unique.