Precast Concrete Piles Provide Durability, Versatility

Precast, prestressed piles offer a range of advantages, particularly in corrosive environments, but proper installation is the key to maximizing the advantages.

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Precast, prestressed concrete piles often are the preferred choice for durable and economical foundations, especially in marine environments, due to their excellent versatility and resistance to corrosion. A range of sizes and shapes are available, and the material’s manufacturing process continues to create new techniques that expand its potential. But to maximize the benefits of precast piles, engineers and contractors must recognize the related handling and installation methods.

Smaller pile sizes, 10 to 14 inches, often are used for building projects such as convention centers, hotels, parking structures, and other large facilities. Larger piles, as big as 66-inch-diameter hollow cylinder piles, are used for bridges and as columns at bents in marine applications. Prestressed concrete piles can be designed to safely support the heavy vertical loads imposed by these types of structures as well as the horizontal loads caused by the range of factors, from traffic, wind, and earthquakes to waves and vessel impact.

Prestressing Is Key

The key to precast concrete piles’ strength lies in the use of prestressing techniques applied during manufacture. Typically, prestressing is applied to piles using pretensioning steel strands in long line casting beds. In most cases, the prestressing strands are the only longitudinal reinforcement in the piles. The prestressing process introduces compression into the pile, which counteracts the tensile stress resulting from handling, driving eccentricity, and stress waves generated during driving. Under service conditions, this compression allows piles to resist axial tension and bending stresses.

Concrete strength for precast piles is usually a minimum of at least 5,000 psi. Precast piles can be fabricated with high-strength concrete that can reach strengths as high as 8,500 if needed. Higher strengths, up to 15,000 psi, can be accomplished but is not recommended due to economy and the extra time required to produce the piles.

Precast concrete piles have been used for more than 50 years. In fact, one of the most significant projects to use precast piles will celebrate its 50th birthday in 2006: the 24-mile-long Lake Pontchartrain causeway connecting New Orleans on the south with Saint Tammany Parish on the north. The precast bridge used 54-inch-diameter hollow piles with a 4.5-inch wall cast in 16-foot sections, which were then post-tensioned. The bridge will celebrate its half-century despite the impact of Hurricane Katrina—an indication of precast’s durability and strength.

Key Pile Shapes

In the 1950s, one of the most common shapes was an 18-inch-square section. As demand increased, new shapes, including circular and octagonal, were produced. Larger, hollow designs in these shapes also appeared. Today, a wide range of designs and types of piles are available, varying by region and manufacturer. Most piles, however, are square, octagonal or round (cylindrical) in cross-section.
Square piles are the simplest to manufacture and are generally available throughout the United States. The larger sizes of square piles may be cast with circular internal voids to reduce the pile weights. The voids also will reduce the number of strands necessary to achieve the same effective prestress, but that in turn reduces the bearing capacity if flexural capacity is needed. This shape requires fewer strands to obtain the same effective prestress and reduces the weight of the pile for shipping and handling.

Octagonal piles are popular in most areas due to code changes that make ductility more of a governing requirement for seismic design. Strands typically are positioned in a circular pattern confined within a circular spiral. These piles often are more economical than square piles because of the material savings that can be achieved. They can also be made with circular internal voids.

Cylinder piles often are used with bridges and other marine structures where foundation members require exceptionally large axial, buckling or bending capacities. They also can be extended into pile bents at the superstructure level, eliminating the need for a separate column. In some cases, cylinder piles are spun-cast in segments that are joined together and post-tensioned to form the completed pile.

Another method of producing cylinder piles is with a collapsing coreform, which is placed in the form and held in place during the concrete pour. After the concrete has reached

Precast, prestressed concrete piles are available in a wide range of shapes.

This 12-inch, 85-foot-long precast, prestressed pile is being driven with a hydraulic hammer that includes an auger on the side so the pile can be dropped into a 55-foot-deep hole prior to driving it.
sufficient transfer strength, the core is collapsed and extracted, leaving the necessary void. This method is favored in high-seismic zones where continuous rebar is required.

Precast concrete piles can be spliced together to create longer piles. They are used primarily where longer piles are required but transportation needs make the longer lengths more difficult or costly to handle due to escort needs and the need for specialized rigs. Transportation limitations vary by region. In some areas, 12-inch piles as long as 115-feet can be transported with no difficulty, and piles up to 135 feet can be hauled with special rigs. When large piles are used on bridge projects, it may be possible to transport the piles to the site on barges, eliminating highway restrictions.

Many Benefits Result

Piles benefit from many of the advantages generally provided by precast, prestressed concrete components. These include economy and reduced energy costs from using local materials and manufacturing, fast, easy and reliable availability, plant-controlled quality of finish and tolerances, and reduced fabrication and construction times. Precast concrete piles offer additional specific advantages:

- **High load capacity.** Prestressed concrete piles provide high axial load-carrying capacities. With a higher allowable load per pile, fewer piles are needed, which may result in smaller footings and generally lower costs per unit of weight supported. In many cases, the key limitation on the axial capacity of prestressed concrete piles is soil condition.

- **High durability.** The combination of dense, high-quality concrete and permanent axial compressive stress along the length of the pile results in a product with minimal cracking and high resistance to moisture penetration. Both experience and accelerated corrosion tests have proven that prestressed concrete piles are extremely durable, even under the most severe conditions of exposure.

- **High adaptability.** Precast piles are highly engineered, manufactured products. As a result, their composition can be adjusted in the fabrication process to include more prestress rebar, higher-strength concrete with more capacity, specific or
Because precast piles are cast under controlled conditions in the plant, they offer a consistent, high quality of fabrication.

unique connections to bridge caps and corrosion inhibitors. Designers can control and adapt the material to ideally suit the specific environment and construction situation into which the piles will be placed.

- Ease of handling, transporting and installing. The uniform axial compression, overall strength and increased lateral stiffness in any direction means that fewer lift points are required. This facilitates transportation and handling and contributes to lower overall installation costs.
- Ability to resist hard driving stresses. The overall strength of the precast concrete piles, together with the axial compression induced by prestressing, permits them to undergo hard driving through loose or dense soils using high-energy hammers. In extremely hard driving conditions, the pile’s ability to resist high tension waves may be improved by increasing the effective prestress.
- Increased capacity and column strength. The relatively large tip area allows prestressed
Considerations When Using

The benefits that precast, prestressed concrete piles can provide make them a strong choice for many applications, but they are not always the specified choice. This is due in some cases to a lack of understanding about their capabilities and unfamiliarity by local contractors with installation methods. Steel piles are well-known, and steel's capabilities are taught in college engineering courses. As a result, graduates arrive in the field with a strong familiarity with those capabilities and load tables. Precast piles are discussed less often, making designers less familiar with how to convert load needs into a moment connection and to determine its location.

And indeed, precast piles require a different driving methodology than steel piles. Typically, a heavyweight hammer with a low impact velocity is used, with a 4- to 5-foot stroke, instead of the 12-foot stroke often used for steel piles. In some soils, high impact velocity, single-acting diesel hammers are used. It also works best to cushion the top of the precast, prestressed pile with 4 to 15 inches of plywood to keep the hammer in contact with the ram longer. This allows it to develop a longer stroke and increases the penetrating power of the pile.

Market Is Growing

The benefits provided by these piles, and the economics of today's construction market, make a strong case for designers and contractors to learn about the potential and specify them more frequently. Although cement prices have been rising, prices for other materials have risen considerably more, making precast concrete piles a strong economic competitor.

Precasters are reporting more and more designers and contractors are finding applications for precast, prestressed piles as contract budgets are strained. This leads to a wider use of the piles and a better, higher-profile understanding of the many benefits they provide.

Special thanks to the engineers at Atlantic Metrocast in Portsmouth, Va., Bayshore Concrete Products in Cape Charles and Chesapeake, Va., Davis & Floyd Inc. in Greenville, S.C. and Pomeroy Corp. in Perris, Calif., for their contributions to this article.