Post-tensioned concrete comes of age: while traditional reinforced concrete construction hasn't changed much in the past four decades, post-tensioned design and construction methods have become simpler

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Post-tensioning (P-T) dates back to the beginning of the twentieth century but was not seen in the United States until the construction of a bridge in 1949. In the 1960s, with the development of higher strength steel, better attachment hardware, better construction techniques, and simplified design methods, the use of P-T to reinforce structures became more popular. By the early 1990s the mystery of P-T subsided with further refinements to the tensioning process, the development of more corrosion-resistant anchorages, and the widespread dissemination of design software. Because of these factors, P-T has become a preferred method for reinforcing concrete today.

Reasons to consider P-T include the following:

* Concrete slabs are thinner, and consequently lighter and less costly.

* Slabs reinforced with P-T have less deflection.

* Joints in a P-T slab are minimized or eliminated.

* Curling in slabs is greatly reduced or eliminated.

* P-T often costs less and is much faster to install than standard rebar methods.

* For foundations, P-T is an effective way to deal with unstable soil.

* P-T improves the long-term durability of structures, especially bridges.

* Span lengths can be greatly increased.

* Concrete tanks can be made as watertight as steel tanks, with far greater durability.

Defining terms

Concrete is strong in compression and weak in tension. "Plain" (unreinforced) concrete is placed when the structure must resist mostly compression forces and when tensile stresses are low. "Reinforced" concrete is used for structures that must resist significant tensile forces. Reinforcing materials (such as steel rebar or welded-wire fabric) that perform well in tension are embedded in the concrete. When loads are applied to the concrete, the bending action causes some of the concrete to be compressed (where it performs well) and some to be in tension (where it tends to crack). The steel reinforcement begins to carry significant load only after the concrete cracks. For that reason it's often referred to as a "passive" reinforcement system.

"Prestressed" concrete is concrete that is pre-compressed by stressing the reinforcement before loads are applied. This greatly increases its ability to resist tensile forces without excessive cracking. Concrete can be prestressed in a factory by tensioning the steel reinforcement first and then placing concrete around it--"pre-tensioned" reinforcement. Or concrete can be cast in place and the steel reinforcement tensioned after the concrete has reached a required strength--"post-tensioned" reinforcement. Structural engineers calculate the limits for tensioning. If the concrete is over-tensioned, serious problems can result. When it's under-tensioned, performance benefits are diminished.

The word tendon encompasses all the components of the P-T system. This includes the "strand," which is usually 1/2 inch in diameter, made from very high-tensile-strength steel wire, usually seven wires twisted together. An anchorage consists of a cast-iron bearing plate and special wedges to secure the strand inside the anchor housing. When the concrete reaches a required strength, one end of the strand is secured and the other end is pulled with a hydraulic jack to its required tension and then secured. "Strands are pulled, initially to about 33,000 pounds; then they relax to about 27,000 pounds," says Cary Kopcyznski, president of Cary Kopcyznski Co., Bellevue, Wash. "One strand is capable of lifting six Chevy Suburbans." Strands are four times stronger than rebar of the same area.

There are two types of P-T systems: bonded and unbonded. Unbonded systems use strands surrounded with special corrosion-inhibiting grease and encased in waterproof plastic sheaths. This assembly is positioned, and then the concrete is placed, similar to standard reinforced concrete. With a bonded system, before the concrete is cast, empty steel or plastic ducts are positioned in the formed area and attached to the anchorages at either end. After the concrete is placed and gains strength, strands are threaded through the ducts, tensioned, and the ducts are filled with a special grout designed to prevent corrosion. Unbonded systems are nearly always used for building and slab construction, while bonded systems are mostly for bridge construction.

Stage stressing is a technique of applying stress to the tendons in stages, as the concrete progressively gets stronger. This technique helps to avoid early cracking in slabs. However, Jerry Holland, Structural Services, Jonesboro, Ga., cautions that you must plan for this carefully. He takes extra cylinders from the last load of concrete that are then tested each day to determine the strength of the slab and the proper tension that can be applied to the tendons.

Where P-T reinforcement is currently being used

As a method of reinforcing, post-tensioning is growing in popularity because it saves money, has many construction advantages, and contractors and designers no longer regard it as a mysterious

method of reinforcement. Also, owners of structures are beginning to understand the process and its benefits. Tendon corrosion problems, an earlier issue, have been overcome by the development of corrosion-resistant tendons and new materials that electrically isolate tendons from the concrete--eliminating the corrosion reaction. Here are the most common types of construction where P-T is now being used.