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Post-Tensioned Concrete Essay

Post-tensioned concrete is concrete that has tensioned steel stands in it that significantly improves the strength of the concrete. Post-tensioning is likely the most impactful innovation in the concrete construction industry since the mid-1800s. Post-tensioning (PT) delivers approximately four times the tensile strength compared to previous concrete construction methods. Post-tensioning also significantly reduces concrete cracking, thus allowing for thinner concrete slab construction. Under those circumstances, the environmental impact is reduced, money is saved on material and labor costs, and construction schedules are shortened. Post-tensioning also brings a host of advantages to combat natural disasters, such as earthquakes and tornadoes. Furthermore, PT structures give architects the freedom to be more creative and artistic.

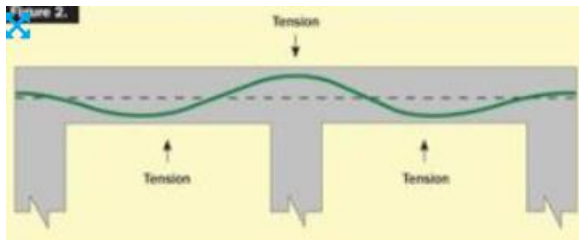


Figure 1: Post-tensioned slab cross section.

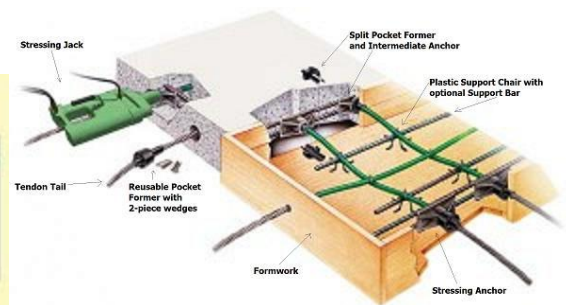


Figure 2: End of slab diagram.

Since the 1950's post-tensioned concrete construction has blossomed in the United States. As a result, technological advancements have significantly improved PT techniques and materials. The original button-headed wire with heavy wax paper wrappings has been replaced by stronger steel, excellent anchorages, injection ports, grout caps, polypropylene ducts, improved grouts, and an array of customizable and more efficient installation techniques. Anchorages, injection ports, grout caps, polypropylene ducts, and improved grouts are all essential parts of the installation process.

Now construction concerns are arising, as PT structures built in the industries formative years need remodeled, repurposed, or repaired. The PT remodel industry steadily grows because generations of structures erected using this technology are coming to the ends of their useful lives. Different methods of repairing are needed because in the 1970s PT was done differently than it was in the 1950s. Consequently, each method of construction gets its own unique method of repairing. Furthermore, in previous generations, life-cycle calculations were not given the importance or precision that they are today, so it is little wonder that older buildings require work to extend their usefulness.

Slab and beam cracking are a common indicator that attention and repairs are needed. Engineers must be consulted to determine the cause. Often the cause is not the concrete or post-tensioning work. Most likely, it is the original design. Design issues likely mean expansive, expensive repairs rather than a localized and inexpensive solution. To the surprise of many engineers, it is often possible to replace the tendons in existing slabs and beams to increase their strength and close the cracking. Another clear sign of an issue in an older building is deflection in any region: slab, beams, columns, walls, or ceiling. Similarly, the engineer must be consulted to find the cause of the deflection and draw up the remodel action plan accordingly. Deflection generally indicates a more serious and expensive issue than cracking. Deflection refers to the bending of a slab, beam, column, wall, or ceiling.

Most structures can usually be remodeled by working on every third strand, one at a time, and proceeding down the slab. This can be a timely method, but it is beneficial because the contractors do not need to erect costly shoring. Shoring is the process of temporarily supporting a structure. Usually, the slab has enough tension reinforcement to absorb the relatively minor, temporary changes in force due to remodeling activity. This technique has been used for single-floor, single-strand replacement to multi-floor cut-outs for elevator shafts and upgraded escape routes. Lastly, this is the most common PT restoration method because of the small effects it has on the tenants or present use of the building.



Figure 3: Post-tensioned slab opening for repair. Figure 4: Tendon being re-stressed after repair.

Surprisingly, a study has shown that it is possible to use lightweight concrete when constructing a concrete slab. The purpose of using lightweight concrete is to create a lighter structure, however lightweight concrete post-tensioned slabs are rare because of their reduced compressive strengths compared to dense aggregate concretes. Another benefit of lightweight concrete is that it behaves differently under loads than dense aggregate concretes do. As a result, lightweight concrete does not undergo the three stages of crack development (I – formation of stable features, II – stable cracks propagation, III – unstable cracks propagation). Rather in lightweight concrete, the cracks run through the aggregate, the weakest part of the bond, resulting in more favorable crack development. It has also been proven that lightweight post-tensioned concrete is also capable of having adequate compressive strength. This study tested the compressive strength of concrete cylinders and found the strength to be 56.9 GPA and 58.4 GPA after 28 days, meeting the requirements from the LC50/55 class. Another concern with lightweight concrete is its increased shrinkage. Due to the lower modulus of elasticity, lightweight concrete can shrink up to 50% more than dense aggregate concrete. As a result, lightweight

concrete post-tensioned slabs should not be used to span long distances but can be a good choice when spanning shorter distances.

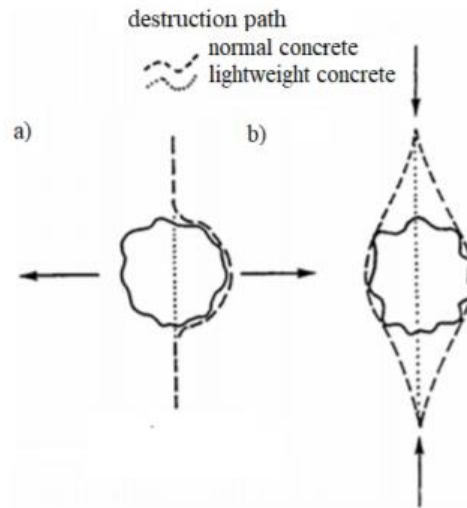


Figure 5: Concrete cracking path (a) tension, b) compression).

Finally, post-tensioned structures perform well during natural disasters. They have much higher structural integrity, resistance, and redundancy during a catastrophic loading event. Post-tensioned parking structures have performed well during earthquakes in the past. Research from the 1971 San Fernando, 1989 Loma Prieta, and the 1994 Northridge earthquakes has shown that PT parking structures have an extremely favorable behavior of moment frames under seismic loads. Furthermore, post-tensioned concrete structures are extremely safe and can be built in areas with the strictest seismic code requirements.

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