Recent Innovations for Enhancing Durability of Post-Tensioning Systems in the USA

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Summary

Recent tendon failures alerted government agencies and the construction industry to improve the design, fabrication, installation and testing of post-tensioning tendons. The largest supplier of post-tensioning materials in the USA, Dywidag Systems International (DSI), redesigned its hardware and revised installation procedures to protect tendons for years to come. Improved grout mixtures and new methods minimize voids and ensure adequate corrosion protection.

Keywords:

Post-tensioning, industry specifications, hardware, installation, inspection, System 100, DYNA Grout, DYNA Force, corrosion protection, vacuum grouting.

1. Tendon Failures and Reactions by the Industry

Post-tensioning has been used in various forms for centuries dating back to ancient history and, by the 1950s, it became an accepted method in concrete bridge construction. Problems discovered during the following decades were directly attributed to corrosion of the tensioning elements. A precast and post-tensioned bridge collapsed without warning in the UK in 1985 and then tendon failures were reported on two bridges in the Florida in 1999 and 2000.

The latest failures became public at the ASBI conference in November 2000 in Brooklyn, New York and sparked an immediate response to form a committee to study the current grouting practices and recommend improvements. Working concurrently, the Post-Tensioning Institute published the first edition of the Specification for Grouting of Post-Tensioned Structures in February of 2001. However, it was the Florida DOT, under the leadership of William N. Nickas, which spearheaded the development of comprehensive specifications covering all aspects ranging from improved grouting materials to installation and inspection.

DSI recognized by the late 1990s that changes in the grouting procedures were essential to protect tendons and therefore increase the longevity of the post-tensioning. Engineers concluded that pre-bagged grout only requiring a fixed amount of water per bag was the way to proceed. The company collaborated with FiveStar to develop and manufacture the thixotropic DYNA Grout as the DSI grout label. This type of grout gels at rest and becomes fluid when agitated or pumped. To mix the thixotropic grout, DSI chose the colloidal mixer since its shearing action produces smoother grout paste. After a while, DSI switched to PT 300 produced by Sika.

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2. System 100 – The DSI Approach

The System 100 encompasses the entire tendon from anchor to anchor. In order to comply with more stringent requirements, DSI redesigned the entire hardware from one end to the other.

- The anchor casting has dual grout ports to allow for an inspection with a straight drill bit behind the wedge plate to check for undesirable grout void or bleed water in the tendon. The tendon may be grouted either from the top port or from the front.
- Permanent FRP grout caps provide additional corrosion protection at the anchorage. These caps have been redesigned to comply with the stricter specifications to cover the wedge plate and anchor face. DSI grout caps are designed to hold 250 psi of pressure.
- The trumpet, made from polyethylene containing antioxidants and attached using a closed cell neoprene seal, complies with specifications for ensuring an airtight tendon system.
- DSI in collaboration with GTI designed a corrugated grout duct manufactured from non-colored, unfilled polypropylene. Longitudinal ribs facilitate the flow of grout while channels help to expel air bubbles from the circumferential ribs of the duct.
- Using a tendon duct coupler, it is possible to couple the duct at the joint in segmentally constructed box girder bridges, thus achieving an airtight tendon even across the joints.
- The DYNA Force system measures the magnetic field in the tendon to determine the stress in the steel. Regular monitoring the change in stress allows for the proactive prevention of problems that may lead to the failure of the post-tensioning system.

3. Field Implementation of Post-Tensioning Systems

Fully grouted post-tensioning ducts have proven to be the most vital component in protecting the prestressed steel. Overhauls in the handling, installation and grouting of post-tensioning systems ensure that, with proper workmanship, an airtight seal can be achieved to protect the tendons from corrosion. Various components snap together, have heat shrink sleeves or are sealed by a closed cell neoprene blend foam. Industry practice demands conducting repeated pressure tests in situ, pumping in compressed air up to specified pressures to detect any significant leakage that may, over time, cause corrosion. Grout caps and other accessories such as inlets and outlets are installed after stressing but before grouting and must be validated by yet another pressure test.

The industry developed and implemented an improved set of grouting procedures. The grout should be pumped into the tendon using a “one-way” flow, beginning at the initial anchor or at an intermediate low point in the profile and should not be reversed at a vent ahead of the flow that may trap air. Most Specifications require inspections within 48 hours after grouting, checking for air pockets in the high points and that all inlet and outlets are completely filled with grout. Upon detecting a void, it may be examined with an endoscope to determine its extent and may be filled using the vacuum grouting method, consisting of withdrawing air with a vacuum pump. The success is measured by comparing the volume of injected grout to the volume of the initial measured void, minus the estimated volume in hoses, canister and measuring device.

4. Conclusion

Proper grouting is as important as any phase during construction of a post-tensioned structure, since its lifetime depends on fully grouted and well-protected tendons. Improvements in designs, hardware and training of workers will prove significant for years, allowing the construction industry to regain confidence in the integrity and desirability of post-tensioning systems.