

Durability of Post-Tensioning Systems: The Details Matter

by Timothy Barry, RS&H

Today's post-tensioning (PT) industry is facing scrutiny due to performance issue on projects that have been deemed to be in violation of project specifications. In some locations, owners are questioning the viability of post-tensioning rather than investigating root causes and implementing improved procedures. With proper planning and execution, however, the industry has repeatedly shown that any PT project can be successful by implementing quality specifications, using quality materials, and performing the work the right way. Attention to detail matters during these operations, and it has been proven time and time again that shortcuts can lead to major problems.

Preconstruction Commitment

Like all construction projects, success depends on the level of engagement of all stakeholders. This starts with the owner and designer instituting the right specifications for the project. The PT industry has developed effective specifications over a number of years to account for many lessons learned. The Post-Tensioning Institute's (PTI's) and American Segmental Bridge Institute's (ASBI's) *PTI/ASBI M50.3-12 Guide Specification for Post-Tensioning* and the *PTI M55.1-12: Specification for Grouting of Post-Tensioned Structures* are examples of valuable resources providing owners a comprehensive specification that can lead to a quality final product.

These specifications provide a starting point for owners and have proven to be effective through years of use. In these specifications are various personnel requirements for years of experience and specific training. These requirements, already implemented on numerous projects, have proven to be an effective way to achieve the desired construction quality. Owners should enforce similar requirements for inspection staff as well. The owner should have their own expertise, which is equally qualified, and that is looking out for the owner's long-term



Grout mixing operations. All Photos: RS&H.

interests. Understanding the specifications and their specific intent goes a long way toward institutionalizing quality through construction.

Grouting Operations

A diligent commitment to proper grouting procedures has been shown to be one of the most effective ways to alleviate durability issues. The current PT industry specifications, when used properly, have proven to be very effective in achieving fully grouted tendons. All parties need to understand that there can be no shortcuts or missed steps when it comes to grouting procedures. This includes buy-in from the contractor's personnel and the inspection staff at all levels of the project. This buy-in starts with the respective project managers from the contractor and the owner creating this culture of high-quality construction. It should be understood from the top that commitment to quality and adherence to proper procedures are expected.

Inspection oversight of grouting operations has become one of the most important jobs in the PT industry. There have been too many examples where flawed inspection, or simply lack of inspection, was noted on projects that experienced problems with tendon durability. No part of the grouting

operation can be overlooked and strict adherence to procedures is the key. Like many things in life, preparation ahead of time improves the potential for success. For PT grouting, preparations include knowing the storage condition of the grout, tracking the expiration dates of the grout, and establishing the proper water-cement ratio, exact batch parameters, theoretical volume for the day's operation, efflux testing of the mixed grout, unit weight of the mixed grout, inlet and outlet locations, and the sequence of operations. These are all items of information that can and should be determined long before the first batch of grout is mixed.

Everyone involved in the grouting process must be aware of the details in the project specifications. Without exception, these details must be understood and followed explicitly. This translates directly to the project specific grouting plan that will be developed and approved to achieve the owner's expectations. Development of the plan should address batching parameters, equipment, grouting sequence, methods of maintaining proper grouting pressures, material testing, and observation of the operations. This plan is also a way for the contractor to consider ahead of time how these important details will be handled.



Unit weight testing of grout by mud balance.

Determination of “good grout” in the field is important for knowing when a PT tendon is complete and full. Constant material testing throughout the process is imperative. Testing for bleed water for all grout batches mixed should be performed. There should be careful control of mixing procedures so they do not deviate from specified practices. Monitoring mixture temperatures and checking efflux values are important ways to ensure control of the grout material as it is being batched and pumped. During grouting operations, grout quality is monitored and maintained using the unit weight determined by a mud balance and the efflux rate determined by a flow cone.

The grout should be tested prior to pumping into the inlet with the unit weight and efflux rate recorded. At the grout outlet, the material is tested again and the results must compare favorably or grout must continue to be pumped. It is at this stage that convenience or schedule cannot override the need for assurance of quality material. The ultimate goal for all of these steps is a fully grouted PT tendon with properly mixed grout. Attention to detail and commitment to the process will go a long way towards that goal.

Post-Grouting Inspection

The final step in the process is visual inspection of the grouted PT tendons. Post-grouting inspection should be performed for all grouting operations, regardless of the size of the project or the scope of the operations. Visual inspection and sounding of PT tendons are two ways to quickly identify issues and provide a means to effectively address any issues before they can have long-term effects on the structure. If identified immediately, the contractor can remedy any voids discovered and eliminate the problem prior to the completion of construction. This final procedure provides the owner



Flow cone testing of grout.


an additional level of assurance that grouting operations were successful. Visual inspection should not be overlooked or skipped as it is an integral part of the process for successful grouting operations.



Post-grouting visual inspection using a borescope.

Moving Forward

Grouting of PT tendons remains among the most important aspect of PT construction. It also remains one of the most scrutinized practices in the PT industry. The number of improvements the PT industry has made over the past 20 years is far too numerous to name here and the industry continues to head in the right direction.

At the most basic level, quality of the graded product will always be a reflection of the quality of the construction. Therefore, it is incumbent upon the PT industry to make sure these improvements are being executed to their fullest extent by strict adherence to the details and proper oversight of the construction. We have seen time and time again that even minor deviations from proper procedures can greatly impact the final product. Commitment by all parties, including the owner, designers, inspectors, and contractors, to doing things the right way will assure that the PT industry will perform in compliance with its outstanding publications, testing procedures, and certification programs. 

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