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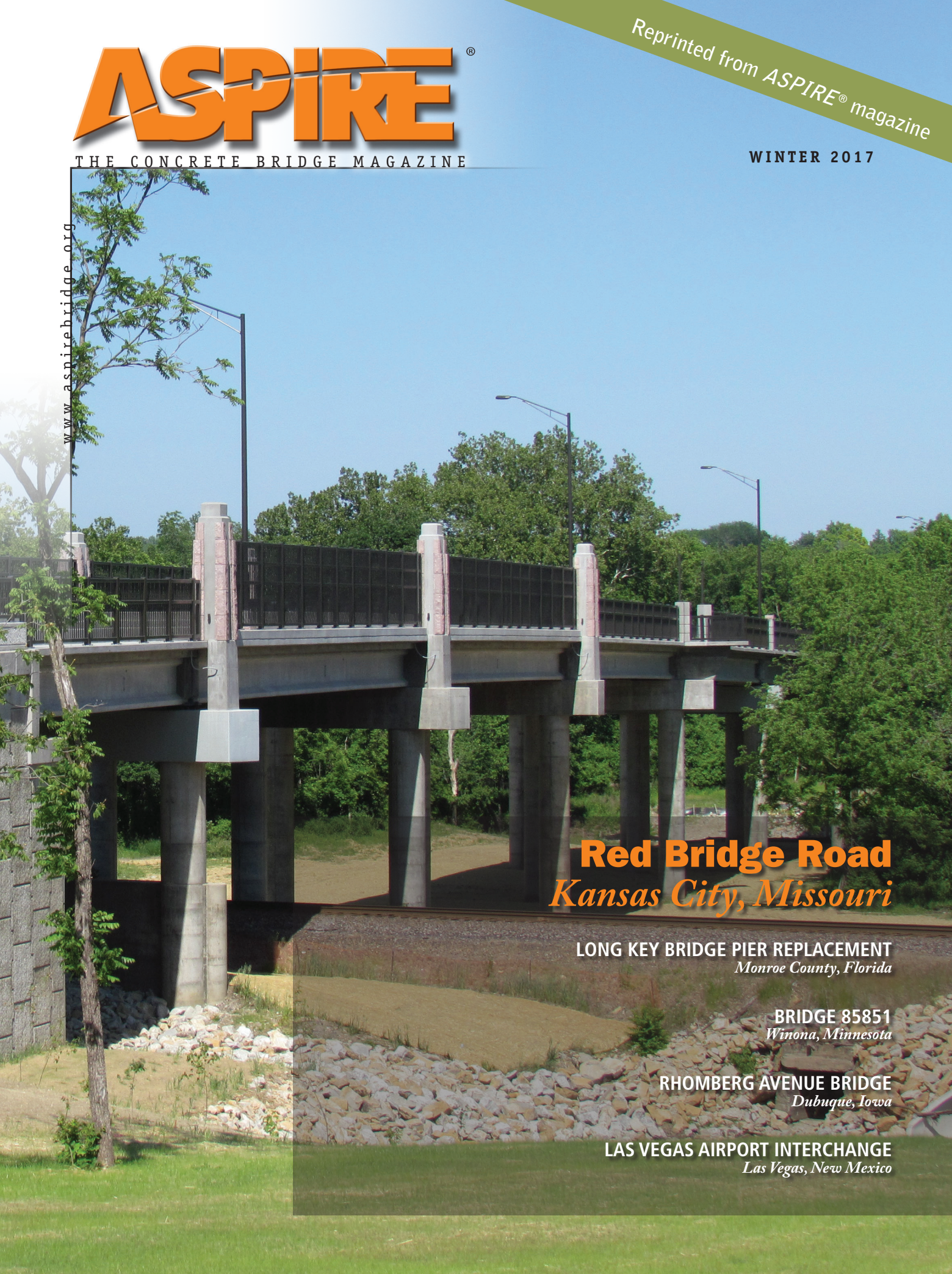

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EDITORIAL

Responsibility, Authority, and Accountability

By W. Randy Cox, ASBI; Theodore Neff, PTI, and William N. Nickas, PCI

More than 15 years ago, the concrete bridge industry in the United States became aware of several isolated performance issues related to grouted post-tensioning (PT) tendons. In response, several responsible stakeholders—owner agencies, consultants, contractors, and technical institutes—mobilized to rectify and improve the state-of-the-practice. New PT durability details to enhance tendon protection and facilitate post-construction inspection were incorporated. Proprietary prepackaged grout materials were developed to replace field formulations and to improve overall grout performance. The technical institutes created education and certification programs related to PT grouting practices. Updated project specifications soon began to incorporate requirements for these certifications, the enhanced details, and the new grouts. The bridge engineering and construction community demonstrated it could work together to improve the long-term durability of post-tensioned bridges.

Later, experience showed that the use of the prepackaged grout materials had unintended consequences. While the engineered grouts were generally very effective in controlling grout bleeding, which had been the cause of most of the reported problems 15 to 20 years ago, some were found to be susceptible to a new problem—namely, segregation or soft grout. Research has shown that some of these proprietary mixtures included a high percentage of inert material that contributed to the formation of soft grout in some instances—particularly when excess water was used. When these new performance issues were reported in 2009, the industry again responded by revising the Post-Tensioning Institute grout material specification, M55, to prohibit the addition of inert fillers.

At the 2016 annual meeting of the AASHTO Subcommittee on Bridges and Structures, a state department of transportation (DOT) engineer reported that a bridge constructed in 2007 with prepackaged grout materials was now in distress. The DOT representative reported that the PT tendons contained grout with an excess amount of water—estimated to be twice the manufacturer's recommended level.

These experiences have shown that both quality materials and proper workmanship are needed to achieve reliability and long-term performance. The industry responded again with new specifications and new technologies. For more information, see the articles on pages 32, 34, and 36 in this issue.

When specified work procedures performed by qualified personnel go awry, corrective actions and perhaps revised jobsite procedures are needed. Conversely, the positive results achieved from consistently practicing quality work that leads to the good long-term performance of the vast majority of PT bridges should also be recognized.

During a recent safety workshop, presenter Michael Peelish used a slogan, "RAA" standing for **responsibility**, **authority**, and **accountability**. "RAA" can be defined for our industry as follows:

- **Responsibility**–the obligation to ensure that appropriate action is taken to follow the plans and specification procedures developed through standards of care from industry and set forth in the contract documents
- **Authority**–the jurisdiction and right to decide and take action to achieve a compliant installation by the installers and inspectors
- **Accountability**–to be answerable to the specified entity and the jurisdictional authority for a particular process or procedure

Prime construction contracts and subcontracting agreements must include the following items for assurance and to foster an accountable system:

- Clearly specify authority and responsibility of each party
- Provide adequately qualified (certified and permitted) personnel to meet the assigned responsibilities
- Conduct independent monitoring and assessment of individual processes
- Establish appropriate consequences for noncompliance or failing to take action
- Ensure consistent and unbiased application of accountable standards

We must do a better job of controlling quality, identifying problems during construction, and taking appropriate corrective action when necessary. We cannot rely solely on updated specifications to replace reliable workmanship and inspection. The entire bridge industry must make quality the responsibility of every single person involved in the project.

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ASPIRE® *editorials are usually written by the editor-in-chief. However, recent issues in the bridge community compel us to use this space to address an industry issue.*

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 rathr 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.

Grout mixing operations. All Photos: RS&H.

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 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.

Flow cone testing of grout.

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 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.

Timothy Barry is the Virginia-East regional leader for RS&H in Virginia Beach, Va.

The Quality Partnership: Ensuring the Performance and Reliability of Post-Tensioning Installation and Grouting

by Theodore L. Neff, Post-Tensioning Institute

Concerns are being raised about post-tensioning (PT) grouting and installation, even though the majority of PT bridges worldwide are performing well and without problems. Why then the concern?

Several highly publicized problems have focused attention on PT bridge construction, and particularly on grouting. While actual cases of poor grouting are very few in number, these problems have shown that quality has not always been achieved and better reliability is needed.

Quality and Reliability

In an ideal world, everyone on the project team would share responsibility and ensure that everything is done right and with the highest quality possible. But as experience has shown in all aspects of construction, "stuff" happens. Whether it be from inattention, ignorance, inexperience, neglect, competitive pressures or simply bad luck, things do not always go according to plan.

Identifying Problems and Ensuring Quality Construction

Recognizing that some problems are inevitable, it is critical that appropriate controls are in place to ensure that these situations are identified and appropriate corrective/preventive actions are taken in a timely manner. To do so effectively requires the following:

- Good plans, specifications, and project details
- Quality control by the contractor and all of its subcontractors and suppliers
- Quality assurance by the owner or specifier
- Education and training of all personnel involved in the construction process

All are needed to consistently achieve a high degree of reliability.

Plans, Specifications, and Details

Plans, specifications, and details are typically the responsibility of the owner's engineer. Suitable plans and details greatly impact constructability and are the foundation for achieving quality. Poor details, such as improper location of grout inlets and outlets, may lead to voids and difficulty in completely filling a duct with grout. Furthermore, effective specifications "set the bar" for quality and ensure that the owner's performance and reliability objectives are met. Alternatively, lax specifications may put contractors, who are trying to do a good job, at a competitive disadvantage, and entice them to a hurried schedule without properly controlled processes to stay competitive.

Effective specifications "set the bar" for quality.

Contractor Quality Control

The contractor must have adequate quality control (QC) measures in place to ensure that the completed construction meets the owner's requirements as detailed in the plans, specifications, and other contract documents. This responsibility also applies to all of the suppliers and subcontractors on the project.

Often materials and products are pre-approved through ASTM testing or a qualification program before the project begins. However, as was learned the hard way with prepackaged grout in the PT industry, it is important that manufacturers have an ongoing QC program to ensure that their materials and products continue to meet project requirements throughout production and not just during initial qualification.

It is important that manufacturers have an ongoing QC program to ensure that their materials and products continue to meet project requirements.

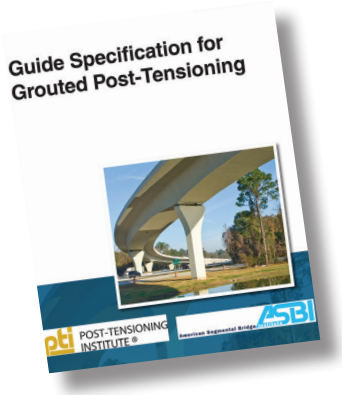
Contractor QC must take into account the coordination and interaction of different subcontractors and operations that impact quality of the post-tensioning construction. If left solely to a subcontractor, there are often factors that are beyond the subcontractor's control. For example, reinforcement conflicts or misaligned ducts in precast concrete elements can lead to difficulties in PT installation and subsequent grouting. In these cases, the PT installation subcontractor is responsible for installation and grouting but may not have any control over the quality of other subcontractors' operations. The contractor's oversight and jobsite testing (for example, flow cone, density, and pressure testing) at critical points is essential to ensuring the quality of subcontractor work.

Owner's Quality Assurance

Quality assurance (QA) is normally the responsibility of the owner or its representative. Acceptance testing and related payment items are keys to a successful QA program. Enforcement of specification requirements is vital to achieving quality on the immediate job, as well as future projects.

Timely inspection of PT installation and grouting before a contractor leaves a jobsite

generally means that corrective action, when necessary, will be easier than later when the structure is in service. For example, inspecting tendons shortly after grouting will identify voids, if any, that can be filled using vacuum grouting techniques while the grouting crew is still onsite. Furthermore, when problems are discovered early and a contractor must correct errors before being paid, it serves as a powerful economic incentive to do it right in the first place.



Education and Training

Qualified personnel are the "grease" that makes the construction process run smoothly. Having installers who know what they are doing, designers who are familiar with PT construction and related details, and inspectors who know what to look for and why, are essential to achieving quality with a high level of reliability.

PTI Quality Efforts

The mission of the Post-Tensioning Institute (PTI) is to promote quality and advance the state-of-the-art of post-tensioned concrete design and construction. PTI has several activities that are intended to enhance quality of PT installation, including the following.

Standards and Specifications

The joint *PTI/ASBI M50.3-12: Guide Specification for Grouted Post-Tensioning* and the *PTI M55.1-12: Specification for Grouting of Post-Tensioned Structures* provide consensus-based standards that represent the latest state-of-the-art in PT bridge construction. These specifications are being continually updated by PTI's technical committees, with membership representation from industry, academia, and owners. In addition, PTI is developing a new program to evaluate and qualify multistrand and bar PT systems. Updated editions of both specifications as well as the launch of the PT System Qualification Program are expected in early 2017.

Education and Training

PTI and ASBI certification programs provide education and training for field personnel. The existing PTI Bonded PT Field Installation and the ASBI Grouting Certification courses provide in-depth training on installation and grouting of PT tendons. A new companion program focused on inspection of bonded PT systems is being developed by PTI and will be available in early 2017.

Once in place, it is planned that a provision be added to the M-50 specification which would require a contractor to hire a certified third party inspector to oversee PT installation and grouting QC unless waived by the owner. This self-policing requirement would greatly strengthen contractor QC and minimize problems that go undetected and uncorrected.

Keys to maximizing quality of PT installation

- Train personnel.
- Use standard specifications and details.
- Require contractor/supplier quality control.
- Require acceptance testing and inspection.
- Enforce contract requirements.
- Identify problems and take timely corrective action.
- Communicate.

Research

In 2017, PTI will sponsor research with a two-fold objective:

- First, study the suitability of using cement that meets the American Petroleum Institute's API 10-A, *Specification for Cements and Materials for Well Cementing,* as PT grout. API well cements are produced to a much tighter specification standard with frequent QC testing, which may lead to reduced variability and improved reliability.
- The second phase of the study will be to evaluate the effectiveness and accuracy of in-line density meters in PT grouting. Automatic in-line density meters are widely used to monitor soil slurries, and have the potential to provide continuous, real-time monitoring of water content in PT grout.

Summary

Experience has shown that perfection in construction quality is probably not possible, but our goal should be to come as close as possible and realize a degree of reliability consistent with the owner's needs. With a team approach where all parties—the PT installer, the general contractor and related subcontractors, the designer and the owner—take responsibility to pursue and achieve quality, a high degree of reliability and performance is not only possible, but likely.

Theodore L. Neff is the executive director of the Post-Tensioning Institute in Farmington Hills, Mich.

Implementation of Flexible Filler for Post-Tensioning Corrosion Protection in Florida

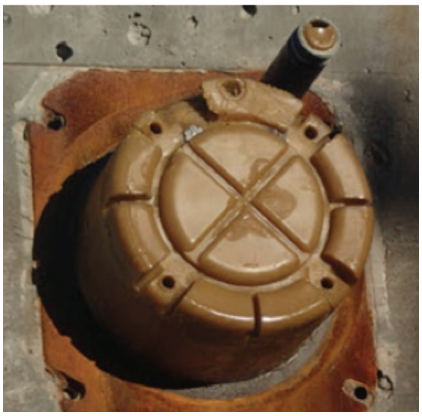
by William R. Cox, American Segmental Bridge Institute

On January 28, 2015, the Florida Department of Transportation (FDOT) issued Structures Design Bulletin 15-01, "Update to Revisions to Policy for Post-Tensioning Tendons," mandating the use of flexible filler, in lieu of cementitious grout, for corrosion protection of certain post-tensioning (PT) tendons for projects under design beginning in 2015. Currently, the only FDOT-approved flexible fillers are microcrystalline petroleum-based waxes that are heated until liquid then injected to fill the PT tendon duct, providing long-term corrosion protection of the PT tendons. When flexible fillers are used, the PT tendons are designed to be unbonded and fully replaceable. Table 1 shows the required corrosion protection materials for post-tensioned tendon types in Florida.

Table 1. Required corrosion protection materials by post-tensioning tendon type

Tendon Type	Filler Material
Top slab cantilever longitudinal tendons in segmental box girders	Grout
Top slab transverse tendons in segmental box girders	Grout
Top slab transverse tendons in segmental box girders	Grout
Straight strand or parallel wire tendons in U-beams and girders	Flexible Filler or Grout
Bar tendons (predominately vertical or horizontal)	Flexible Filler or Grout
All other tendon types	Flexible Filler

Flexible fillers are to be installed under the direct supervision of a filler injection foreman and performed by grouting technicians in the presence of a filler injection quality control inspector. Each of these personnel is required to have an American Segmental Bridge Institute (ASBI) Flexible Filler Certification. Verifiable experience performing injection of similar flexible filler on at least two projects is currently acceptable in lieu of ASBI certification. However, this allowance will be deleted from the FDOT specifications after the first ASBI Flexible Filler Certification Training Course has been given.



Flexible filler encapsulation of post-tensioning wedge plate (grout cap removed). Photo: Florida Department of Transportation.

ASBI, FDOT, and the Post-Tensioning Institute (PTI) are sponsoring the first ASBI Flexible Filler Certification Training Course on May 9-10, 2017.

ASBI, FDOT, and the Post-Tensioning Institute (PTI) are sponsoring the first ASBI Flexible Filler Certification Training Course on May 9-10, 2017, in Tallahassee, Fla. This course is available to foremen, technicians, and inspectors involved with upcoming PT projects in Florida. As a prerequisite to attend the course, participants must hold current certificates as an ASBI Grouting Technician and a PTI Bonded PT Field Specialist. The course will consist of 8 hours of classroom instruction, 3 hours of laboratory demonstrations, and an exam. The course will cover all phases of flexible filler field installation.

Randy Cox is the executive director of the American Segmental Bridge Institute in Buda, Tex.

EDITOR'S NOTE

For information regarding the requirements for the use of flexible fillers on Florida Department of Transportation projects, see the FDOT Structures Manual: http://www.fdot.gov/structures/StructuresManual/CurrentRelease/StructuresManual.shtm.

For information regarding the ASBI Flexible Filler Certification Training, see http://www.asbi-assoc.org/index.cfm/ events/upcoming-events.