SYNTHESIS TO DEVELOP GUIDANCE FOR MONITORABLE, REPLACEABLE AND ASSESSABLE PT TENDONS

Presented to:
AASHTO SCOBS T-18 Technical Committee for Bridge Management, Evaluation, and Rehabilitation

Presented by:
Barton J. Newton, P.E.

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SCOBS
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1. Introduction
2. Technical Working Group (TWG)
3. Research Team Members / Org. chart
4. Goals and Objectives of the Research
5. Overview of Sub-Tasks 1 to 5
6. Sub-Task 2: Monitorable PT Tendons
7. Sub-Task 3: Replaceable PT Tendons
8. Sub-Task 4: Assessable PT Tendons
9. Goals and Objectives of the Research
Timelines and Activities

- August 7, 2014: RFP
- August 22, 2014: Proposal submitted
- September 11, 2014: Task Order 5009 Award
- September 29, 2014: Kick-Off meeting (completed)
- October 25, 2014: 1st Face to face meeting
- December 9, 2014: 2nd Face to face meeting
- January 9, 2015: Submitted Final Work Plan
- Scheduled Project Completion is December 2015

Current Activities

- The sub-tasks 2, 3, and 4 are conducting Phases 1 and 2 of the research activities according to Work Plan
Introduction

Background

- Recent improvements have been made in the design, construction and inspection practices of post-tensioned (PT) bridges in the US. However, our industry should continue to develop new methods and tools to adequately address tendon issues for PT bridges, and ensure long term durability in the future.

- This research project will provide significant opportunity to bring new technologies to US practices such as EIT monitoring, replaceable external PT, and provide a critical assessment of the current construction practices to further improve the existing US practices.
# Technical Working Group Rosters

<table>
<thead>
<tr>
<th>NO.</th>
<th>Name</th>
<th>Affiliation</th>
<th>E-mail</th>
<th>Phone</th>
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<tbody>
<tr>
<td></td>
<td><strong>Government / DOT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Reggie Holt</td>
<td>FHWA</td>
<td><a href="mailto:Reggie.Holt@dot.gov">Reggie.Holt@dot.gov</a></td>
<td>(202) 366-4596</td>
</tr>
<tr>
<td>2</td>
<td>Michael Sprinkler</td>
<td>VDOT</td>
<td><a href="mailto:Michael.Sprinkler@vdot.virginia.gov">Michael.Sprinkler@vdot.virginia.gov</a></td>
<td>(434) 293-1941</td>
</tr>
<tr>
<td>3</td>
<td>Claude Napier</td>
<td>VDOT</td>
<td><a href="mailto:Claude.napier@VDOT.Virginia.gov">Claude.napier@VDOT.Virginia.gov</a></td>
<td>(804) 786-2853</td>
</tr>
<tr>
<td>4</td>
<td>Robert Robertson</td>
<td>FDOT</td>
<td><a href="mailto:Robert.robertson2@dot.state.fl.us">Robert.robertson2@dot.state.fl.us</a></td>
<td>(850) 414-4267</td>
</tr>
<tr>
<td>5</td>
<td>Dan Hurtado</td>
<td>FDOT</td>
<td><a href="mailto:Dan.Hurtado@dot.state.fl.us">Dan.Hurtado@dot.state.fl.us</a></td>
<td>(850) 414-4155</td>
</tr>
<tr>
<td>6</td>
<td>Bijan Khaleghi</td>
<td>WSDOT</td>
<td><a href="mailto:KhalegB@wsdot.wa.gov">KhalegB@wsdot.wa.gov</a></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Leon Flournoy</td>
<td>TxDOT</td>
<td><a href="mailto:Leon.Flournoy@txdot.gov">Leon.Flournoy@txdot.gov</a></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Courtney Holle</td>
<td>TxDOT</td>
<td><a href="mailto:Courtney.Holle@txdot.gov">Courtney.Holle@txdot.gov</a></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Susan Hida</td>
<td>Caltrans</td>
<td><a href="mailto:Susan.hida@dot.ca.gov">Susan.hida@dot.ca.gov</a></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Craig Knapp</td>
<td>Caltrans</td>
<td><a href="mailto:Craig.Knapp@dot.ca.gov">Craig.Knapp@dot.ca.gov</a></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Nancy Daubenberger</td>
<td>MnDOT</td>
<td><a href="mailto:Nancy.daubenberger@state.mn.us">Nancy.daubenberger@state.mn.us</a></td>
<td>(651)366-4501</td>
</tr>
<tr>
<td>12</td>
<td>Dustin Thomas</td>
<td>MnDOT</td>
<td><a href="mailto:Dustin.thomas@state.mn.us">Dustin.thomas@state.mn.us</a></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Jim Ma</td>
<td>Caltrans</td>
<td><a href="mailto:Jim.ma@dot.ca.gov">Jim.ma@dot.ca.gov</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Industry / Manufacturers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ted Neff</td>
<td>PTI</td>
<td><a href="mailto:Ted.neff@post-tensioning.org">Ted.neff@post-tensioning.org</a></td>
<td>(248) 848-3185</td>
</tr>
<tr>
<td>2</td>
<td>Randy Cox</td>
<td>ASBI</td>
<td><a href="mailto:wrcox@asbi-assoc.org">wrcox@asbi-assoc.org</a></td>
<td>(512) 523-8214</td>
</tr>
<tr>
<td>3</td>
<td>Guido Schwager</td>
<td>Schwager Davis, Inc.</td>
<td><a href="mailto:guidou@schwagerdavis.com">guidou@schwagerdavis.com</a></td>
<td>(408) 281-9301</td>
</tr>
<tr>
<td>4</td>
<td>Drew Micklus</td>
<td>Freyssinet</td>
<td><a href="mailto:Drew.micklus@freyssinetusa.com">Drew.micklus@freyssinetusa.com</a></td>
<td>(703) 378-2500 x222</td>
</tr>
<tr>
<td></td>
<td><strong>Consultant</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>John Corven</td>
<td>Corven Eng</td>
<td><a href="mailto:Jcorven@corveneng.com">Jcorven@corveneng.com</a></td>
<td>(850) 386-6800</td>
</tr>
<tr>
<td>2</td>
<td>Brian Merrill</td>
<td>WJE</td>
<td><a href="mailto:BMerrill@wje.com">BMerrill@wje.com</a></td>
<td>(512) 257-4800</td>
</tr>
<tr>
<td>3</td>
<td>Brett Pielstick</td>
<td>Eisman &amp; Russo</td>
<td><a href="mailto:bpielstick@eismanrusso.com">bpielstick@eismanrusso.com</a></td>
<td>(904) 733-1478</td>
</tr>
</tbody>
</table>
Barton Newton, PE
PRINCIPAL-IN-CHARGE

Joe Tse, PE
PROJECT MANAGER

Pepe Garcia, PE
PROJECT OPERATIONS MANAGER / TECHNICAL OPERATIONS MANAGER

Teddy Theryo, PE
Trey Hamilton, PE, PhD (UF)
TASK LEADS

Hans Ganz, PhD (GC)
TECHNICAL ADVISOR

SUB-TASK 1: KICK-OFF MEETING
Piotr Paczkowski, PE, PhD
Ueli Angst, PhD (SGK)
Trey Hamilton, PE, PhD (UF)
Teddy S Theryo, P.E.
Piotr Paczkowski, PhD

SUB-TASK 2: MONITORABLE PT TENDONS
Markus Büchler, PhD (SGK)
Victor Ryzikov, SE, PE
Antonio Ledesma, PE

SUB-TASK 3: REPLACEABLE PT TENDONS
Teddy Theryo, PE

SUB-TASK 4: ASSESSABLE PT TENDONS
Ian Hubbard, PE
Rico Lepore, PE (Deputy)
Trey Hamilton, PE, PhD (UF)
Greg Hunsicker, PE (VSL)
Donald Green

SUB-TASK 5: QUARTERLY REPORTING
Piotr Paczkowski, PE, PhD
Admin Support
Pepe Garcia, PE

Management &
Admin Support
Pepe Garcia, PE
Piotr Paczkowski, PE, PhD
Goals and Objectives of the Research

- Advance the ability to monitor, replace and evaluate future Post-tensioned bridges
- Improve durability of future PT bridges using available continuous monitoring tools
- Improve quality of future PT bridges through a improved construction inspection and material testing procedures
- Develop specification language for Sub-Tasks 2 and 3 to be included in the PTI/ASBI M-50 “Guide Specification for Grouted Post-tensioning”
- Develop guidance for Bridge Owners
- Develop a two hour Power Point presentation for outreach and educational purposes
The following Sub-Tasks 1 to 5 were established according to FHWA RFP Section 1.3

- **Sub-Task 1: Kick-off Meeting**
  - Kick-off meeting (completed)
  - TWG formation (Completed)
  - Develop Work Plan (Completed)
- **Sub-Task 2: Monitorable PT Tendons**
- **Sub-Task 3: Replaceable PT Tendons**
- **Sub-Task 4: Assessable PT Tendons**
- **Sub-Task 5: Quarterly Progress Reporting**
Sub-Task 2: Monitorable PT Tendons

Research Team members

Team Leader: Dr. Markus Büchler

Members: Dr. Ueli Angst (develop EIT guidelines / manual)
	Dr. Trey Hamilton, PE (specification language, testing )
	Teddy S. Theryo, P.E. (Specification and implementation)
	Dr. Piotr Paczkowski, PE (assisting the team)
Technical Approach

The research approach is divided into several phases of activities:

**Phase 1:** Review literatures of existing Swiss manuals and other countries (if available) for adoption to US application

**Phase 2:** Develop EIT manual / guidelines, included component requirement, installation, performance test, monitoring device, procedures and QA-QC for US implementation

**Phase 3:** Develop specification language plus texts for inclusion in the PTI/ASBI M-50 “Guide Specification for Grouted Post-Tensioning”

**Phase 4:** Develop a two-hour Power Point presentation plus texts
Sub-Task 2: Monitorable PT Tendons

- **PL₁A**: duct with filling material providing durable corrosion protection.
- **PL₁B**: PL₁A plus engineered grout and permanent grout cap.
- **PL₂**: PL₁B plus an envelope, enclosing the tensile element bundle over its length, and providing a permanent leak tight barrier (encapsulation).
- **PL₃**: PL₂ (encapsulation) plus Electrical Isolation Tendon (EIT) to be monitorable or inspectable at any time.

PTI /ASBI M50 “GUIDE SPEC. FOR GROUTED PT” PROTECTION LEVEL
Sub-Task 2: Monitorable PT Tendons

(Courtesy of VSL International)
Sub-Task 2: Monitorable PT Tendons

Internal Bonded Tendon

Cast-in-place Bridge On Falsework (potential application)
Sub-Task 2: Monitorable PT Tendons

Grout cap

EIT Cable
Sub-Task 2: Monitorable PT Tendons

Monitoring /Measuring Box

EIT Cables
Protective shell and plastic tie at duct support in the tight tendon curve zone
Access of aggressive substances to the steel is blocked

Efficiency of the insulation can be controlled

Corrosion rate is decreased in case of activation
Sub-Task 3: Replaceable PT Tendons

Research Team members

Team Leader: Teddy S. Theryo, PE

Members: Antonio Ledesma, PE (develop replaceable external PT standard details)

Victor Ryzhikov, PE, SE (PT tendons replaceable concept)
Sub-Task 3: Replaceable PT Tendons

Scope of Work

1. Review the current practices of replaceable external tendons in other countries
2. Perform a parametric study of tendon radii of curvature for different sizes of tendons in diaphragms, blisters and deviators
3. Develop different shapes and sizes of diabolo designs applicable to diaphragms, blisters and deviators
4. Develop standard details for selected replaceable PT tendons concept in deviators, blisters and diaphragms
5. Recommendations for future development and testing if needed
Sub-Task 3: Replaceable PT Tendons

Technical Approach

The research approach will be divided into several phases of activities:

Phase 1: Review literature, test results, and standard practice in other countries

Phase 2: Explore several replaceable external PT Tendons concepts

Phase 3: Geometric study of selected bridge projects with external PT Tendons

Phase 4: Develop standard details for fully replaceable external PT tendons

Phase 5: Develop specification languages and commentary to be proposed to PTI/ASBI M-50 Committee for inclusion in the “Guide Specification for Grouted Post-Tensioning”

Phase 6: Develop a two hour Power Point presentation for educational/training and outreach purposes, including speaker notes
Sub-Task 3: Replaceable PT Tendons

Typical Span by Span segmental bridge with external tendons
Sub-Task 3: Replaceable PT Tendons

Existing US Details in Deviator

Steel Pipe Embedded in Concrete

Neoprene Boot Coupler
Sub-Task 3: Replaceable PT Tendons

- Diaphragm (typ.)
- Steel pipes
- Deviator (typ.)

Existing US grouted external tendon detail
Sub-Task 3: Replaceable PT Tendons
Sub-Task 3: Replaceable PT Tendons
Sub-Task 3: Replaceable PT Tendons
Sub-Task 3: Replaceable PT Tendons

Double Pipe Detail in the Diaphragm

Half Shell PE Deflection

Diaphragm
Sub-Task 3: Replaceable PT Tendons

Pulling Prefabricated Tendons Inside a Box Girder
Protection of tendons during pulling operation
Sub-Task 3: Replaceable PT Tendons

DEVIATOR @ QUARTER POINT
Prefabricated Tendons End at Anchorages
Sub-Task 3: Replaceable PT Tendons

- Bearing plate
- Guide pipe (recess tube)
- Concrete
- Void
- Tension ring
- PE duct
- Steel pipe
- Heat Shrink Sleeve
- Anchor head (wedge plate)
- Trumpet
- Protective cap
- Grout port
- Shim plate
Sub-Task 3: Replaceable PT Tendons

Inspection and maintenance Gallery at abutment for replaceable external tendons

End Diaphragm

Abutment
Sub-Task 4: Assessable PT Tendons

Research Team members

**Team Leader:** Ian Hubbard, PE

**Deputy Team Leader:** Rico Lepore, PE

**Members:**
- Dr. Trey Hamilton, PE (PT Grout testing procedures for material approval and during construction)
- Gregory Hunsicker, PE (PT inspections and grouting procedures)
- Donald Green (assisting the research team)
Sub-Task 4: Assessable PT Tendons

Scope of Work

Collect and assess data and opinions on how well the PT construction industry is doing in terms of inspection and testing and our ability to forecast long term performance.

Sub-Task 4 will collect data to help answer the following:

- What is working well?
- What is not working so well?
- What recent improvements have been made?
- How good is the current documentation methods?
- What documentation is being collected to provide certainty of service life expectations?
- Where and how can we improve for overall quality?
Technical Approach

Phase 1: Data Collection

Phase 2: Analysis of Data

Phase 3: Identification of Critical Risks

Phase 4: Comparison to Inspection and Testing Procedures of Other Equally Important Bridge Components

Phase 5: Recommendations for Providing an Initial Bill of Health or “Birth Certificate

Phase 6: Recommendations of changes to current Inspection and Testing Procedures and identification on any new promising developments
Phase 1 - Data Collection

Thirteen States with a history of and/or active bridge construction programs that include post-tensioning elements have been contacted.

Texas, Florida, California, Colorado, Virginia, Utah, Washington, Minnesota, Ohio, New York, Maine, Oregon, Massachusetts

Questions posed to contractors, precasters, PT suppliers, grout suppliers and consultants will be similar to those posed to State DOTs but may be modified for specific expertise of these organizations.
Phase 1 - Data Collection

- Project Specifications for post tensioning and grouting
- PT standard details and protection levels
- QC & QA roles, responsibilities and experience requirements
- Job records to include material certs, field tests conducted, sampling frequency of testing and Pass/Fail rates, Laboratory (acceptance) testing vs Field (production) testing
- PT field construction inspection and testing methods, post grouting inspections, PT Pour backs, Anchor sealing
- Issuance of Non-conformance reports, follow up, close out documentation and Acceptance.
Phase 2 – Analysis of Data

- Materials or System Qualification (prior to construction)
- QA/QC of materials
- QA/QC of construction methods
- Deficiencies left during construction
- Visual inspection findings (during and post construction)
- Destructive testing results (during and post construction)
- NDT methods utilized (during and post construction)
- Corrective actions taken and results
Phase 2 – Analysis of Data

The data will be compiled into a form that presents both qualitative and quantitative results from the collection and survey results.

Evaluation and analysis will validate the ability to qualify systems and materials against the intended or design level of performance. How well does testing identify long-term performance risks?

This information is critical for the identification and characterization of PT system risks, which is covered in the following phase.
Phase 3 – Identification of Critical Risk

- Identify areas of the current PTI specifications (as well as new specifications developed) that are critical to the long-term performance of the structures
- Rank them according to their importance
- Create this ranking system based on experience and the data gathered during the surveys of stakeholders.
- Ranking system could be used during construction as an inspection tool to ensure that the high-importance items are not missed.
- Ranking system used to create an initial Bill of Health or durability rating for the bridge based on the inspection and testing items that have high ratings.
Phase 4 – Comparison of Testing and Inspection Effort

A comparison will be made of testing and inspection “Level of Effort” between post-tensioning and other bridge components of equal importance.

It is recognized that post-tensioning elements are one of the most critical elements in the structure and one of the most likely to necessitate major and costly repair/rehabilitation of the structure if appropriate attention to detail in the design and detailing as well as construction QC/QA inspection and testing is not provided.

We would propose in this section to discuss some of the problems that have surfaced on a number of projects and relate the problems to the known or suspected cause of the problem.

Study will be limited to existing structures with PT issues and this is being or has been covered by others.

Use data from these bridges to illustrate the risks and consequences of problems when they occur and best practices to avoid such occurrence.
Phase 5 – Recommendations for Providing an Initial Bill of Health or “Birth Certificate

The data collected from Phase 1 thru 4 as well as other reference documents such as fib Commission 5 will be used to establish criteria that could be included in a PT Birth Certificate and capture all the engineering information defining form and condition of the PT elements of the structure at the end of construction.

This data will be then available for future comparative assessment of condition of the PT system over the life of the structure and need for repair/replacement of critical PT elements.
Phase 6 – Recommendations of changes to current Inspection and Testing Procedures

From the data collected and our assessment in Sun-Tasks 2 thru 5 we will identify recommendations of changes to current Inspection and Testing Procedures for consideration by other industry committees such as PTI/ASBI M50.3.12.

In addition we will be on the lookout to identify and report on promising PT field inspection and testing methods found during research for possible future research.
Goals and Objectives of the Research

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- Improve durability of future PT bridges using available continuous monitoring tools
- Improve quality of future PT bridges through a improved construction inspection and material testing procedures
- Develop specification language for Sub-Tasks 2 and 3 to be included in the PTI/ASBI M-50 “Guide Specification for Grouted Post-tensioning”
- Develop guidance for Bridge Owners
- Develop a two hour Power Point presentation for outreach and educational purposes