Improved Regionalization of Quality Assurance (QA) Functions (a.k.a. Sharing Inspection Resources)

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17 October 2017

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Outline

- Study Motivation and Objectives
- Review of New England QA processes for PSE/PCE
- Proposed Regionalized QA Process
- Logistics for Regionalization
**Background of QA Procedures for PCE/PSE**

- CFR Title 23 Part 637
  - QA processes ensure that desired level of quality is maintained throughout the manufacturing and construction processes

- AASHTO R38 gives the minimum requirements

- Significant cost savings can be realized if regionally accepted procedures are developed:
  - Inspection and testing resources can be shared
  - Streamlines producer operations when supplying to multiple agencies

- Differences exist between QA procedures of various agencies
1. List of Fabricators Currently (recently) Supplying PSE/PCE to NE DOTs

- PCI Certified Suppliers

<table>
<thead>
<tr>
<th>State</th>
<th>No. of PCI Cert. Fabricators</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>3</td>
</tr>
<tr>
<td>MA</td>
<td>6</td>
</tr>
<tr>
<td>ME</td>
<td>1</td>
</tr>
<tr>
<td>NH</td>
<td>1</td>
</tr>
<tr>
<td>RI</td>
<td>5</td>
</tr>
<tr>
<td>VT</td>
<td>3</td>
</tr>
</tbody>
</table>

Map of New England states with numbers indicating the number of PCI certified fabricators in each state.
1. List of Fabricators Currently (recently) Supplying PSE/PCE to NE DOTs

- NPCA Certified Suppliers

<table>
<thead>
<tr>
<th>State</th>
<th>No. of NPCA Cert. Fabricators</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>3</td>
</tr>
<tr>
<td>MA</td>
<td>6</td>
</tr>
<tr>
<td>ME</td>
<td>1</td>
</tr>
<tr>
<td>NH</td>
<td>3</td>
</tr>
<tr>
<td>RI</td>
<td>1</td>
</tr>
<tr>
<td>VT</td>
<td>3</td>
</tr>
</tbody>
</table>

![Map of New England showing the states and numbers of NPCA certified fabricators](image)
Study Scope and Objectives

- Review of current QA process used by New England DOTs for PCE/PSE
  - Literature review
  - QA Specifications
  - Interviews

- Propose regionalized QA process for PCE/PSE to be used by NETC constituents

- Explore cost-sharing mechanism to accompany the common acceptance standards
Review Methodology

- Information Gathering
  - Preliminary specification review
  - Questionnaire
  - Interviews with constituents
    - Detailed specification and QA process review
  - Fabricator visits (Oldcastle, J.P. Carrara)
    - QA process
    - Feedback
Review Methodology

- Information Processing
  - Master table of the QA process activities
    - Able to develop similarities and differences amongst the agencies.
  - Information was sorted and aspects of QA process were identified that would be most impacted by regionalization
    - Comparisons were made on these aspects and recommendations are generated
Review of State Practices

Brief summary is presented here:

1. Qualification and Certification of Plant/Fabricator
2. Fabricator QC Requirements
3. QA Process (Agency Inspection)
4. Curing Requirements
5. Miscellaneous
1. Qualification and Certification of Plant/Fabricator

- Pre-stress (PSE) Fabricators

| PCI | PCI + Agency Audit | Agency Prequalification |
1. Qualification and Certification of Plant/Fabricator

- Non pre-stress (PCE)
1. Qualification and Certification of Plant/Fabricator: Inspector Office

- Inspector Office/Facilities Requirements
  - RIDOT have the most comprehensive specification detailing the office requirements
  - Other agencies have similar requirements
2. Fabricator QC Requirements

  - PSE
    - *PCI MNL-116 for all agencies*
  - PCE
    - *PCI MNL-116 (MA)*
    - *NPCA (MA, ME, NH, VT)*
    - *Agency specified requirements (RI)*
2. Fabricator QC Requirements

- Qualification of QC Technician
  - PSE
    - PCI Level 2 (All States)
  - PCE
    - ACI Level 1 or 2 (MA, CT, ME)
    - PCI Level 2 (NH)
    - No requirement (RI, VT)
3. QA Agency Inspection

- Employee versus Consultant Inspectors
## 3. QA Agency Inspection

### Inspector Qualification

<table>
<thead>
<tr>
<th>Agency</th>
<th>Prestressed Inspector Qualification</th>
<th>Precast Inspector Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>ACI level 1 equivalent</td>
<td>ACI level 1 equivalent</td>
</tr>
<tr>
<td>MA</td>
<td>PCI Level 2</td>
<td>-</td>
</tr>
<tr>
<td>ME</td>
<td>PCI Level 2</td>
<td>PCI Level 1, 2, or 3</td>
</tr>
<tr>
<td>NH</td>
<td>PCI Level 2</td>
<td>PCI Level 2</td>
</tr>
<tr>
<td>RI</td>
<td>In-House Certification</td>
<td>In-House Certification</td>
</tr>
<tr>
<td>VT</td>
<td>PCI Level 1</td>
<td>PCI Level 1</td>
</tr>
</tbody>
</table>
3. QA Process: Inspection

- Pre-Pour (PSE/PCE)
  - The processes showed strong similarities amongst the six states
    - Comparison of the pre/post pour checklists provided by each agency.
3. QA Process: Agency Testing

- Plastic Concrete Testing
  - Frequency of Plastic Concrete Tests
    - CY, load, lot size, etc.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Spread</th>
<th>Air Content</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td></td>
<td>Witness QC Results</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td></td>
<td>Once per pour</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>First two (2) loads, then at discretion of QAI on basis of consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH</td>
<td>Per sublot (typ. 1/item)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RI</td>
<td></td>
<td>Once per 150 CY or each day’s production</td>
<td></td>
</tr>
<tr>
<td>VT</td>
<td></td>
<td>First load + whenever cylinders are cast</td>
<td></td>
</tr>
</tbody>
</table>

NHDOT also require w/c ratio testing using microwave method.
4. QA Process: Inspection

- Post-Pour (PSE/PCE)
  - The checklists provided by each state varied slightly
    - Maine DOT has the most comprehensive post-pour checklist
  - Watching the element get loaded on transport requirement varies
4. QA Process

- Additional Hardened Concrete Testing
  - Maine and New Hampshire DOT – Permeability testing using AASHTO T-358, “Surface Resistivity Indication of Concrete’s Ability to Resist Chloride Ion Penetration.”
4. **Curing Requirements**

- Ranged from well-prescribed requirements to not being included in the QA process.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Curing Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Not Inspected – Follow MNL-116</td>
</tr>
<tr>
<td>MA</td>
<td>Procedures Under Development</td>
</tr>
</tbody>
</table>
| ME     | MNL-116 with exceptions.  
  • Temperature gain <40°F/hr.  
  • Initial set determined by ASTM C403  
  • Maximum temperature of 160°F  
  • Minimum temperature of 120°F  
  • Until 80% of design strength is achieved |
| NH     | Item Specific |
| RI     | Accelerated curing allowed for PSE |
| VT     | - |
5. Miscellaneous

- Fairly consistent requirements for IA
  - Inspectors are typically IA’ed once per year

- Estimated Inspection Cost
  - The agencies provided an hourly rate estimate for consultant inspectors.
  - It was found that the hourly rate ranged from $50/hour to $100/hour.
    - The lower end of the spectrum does not include travel reimbursement while the higher range incorporates additional costs for travel.
QA Process Review Summary

- Attributes that are most dissimilar between agencies:
  - Sampling frequencies
  - Inspector qualification

- Prestressed concrete element QA processes are more similar between agencies

- Preliminary recommendations are made for regionalized QA process
QA Cost Share Mechanisms

- At present no formal mechanism exists between other States DOTs
- Several DOTs conduct tests for other agencies, standard testing rates are established and costs are typically charged to the project
- Main challenge is costs associated with inspection and on-site testing
Regionalized QA Process Recommendations

1. Three Categories: PSE, Structural PCE, Non-Structural PCE

2. Plant Certification and Producer Testing Requirements

3. Agency Inspection

4. Logistics
1. Recommendation Layout (Categories)

- **Prestressed Elements (PSE)**
  - Examples:
    - *NHDOT Item 528, RIDOT Item 809, MEDOT Item 535*

- **Structural Precast Elements (precast piles, precast concrete superstructure etc.)**
  - Examples:
    - *NHDOT Item 594, RIDOT Item 804, MEDOT Item 534*

- **Non-structural Precast Elements (catch basins, storm drains etc.)**
  - Examples
    - *NHDOT Item 603, RIDOT Item 702, MEDOT Item 603*
## 2. Plant Certification

<table>
<thead>
<tr>
<th>Item</th>
<th>Element</th>
<th>PCI/NPCA Requirement</th>
<th>Additional Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>QC Plan (QSM) and Plant Requirements</td>
<td>PSE</td>
<td>PCI MNL-116</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structural PCE</td>
<td>PCI MNL-116/NPCA</td>
<td>PCI MNL-137 for repair works and AASHTO M-157 for Ready Mix</td>
</tr>
<tr>
<td></td>
<td>Non-Structural PCE</td>
<td>NPCA</td>
<td></td>
</tr>
</tbody>
</table>
### 2. Producer Testing Recommendations (modifications to NPCA/PCI)

<table>
<thead>
<tr>
<th>Sampling and Testing</th>
<th>Item</th>
<th>Element</th>
<th>PCI/NPCA Requirement</th>
<th>Additional Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Casting Bed</td>
<td>PSE</td>
<td>-</td>
<td>Profile and Alignment check</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural PCE</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-structural PCE</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J-Ring or L-Box (AASHTO T-345 or ASTM C 1611)</td>
<td>PSE</td>
<td>-</td>
<td>For each SCC design and at the start of each element type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural PCE</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-structural PCE</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Strength Cylinders</td>
<td>PSE</td>
<td>Minimum of 4 Cylinders per element</td>
<td>Additional 4 cylinders for de-stressing strength</td>
<td></td>
</tr>
<tr>
<td>Structural PCE</td>
<td>4 Cylinders; PCI: Daily for each individual concrete mix, or every 75 CY NPCA: Every 150 CY per mix or once per week</td>
<td>Min. once per each day's production or every 150 CY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-structural PCE</td>
<td>4 Cylinders, every 150 CY per mix or once per week</td>
<td>Min. once per each day's production or every 150 CY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Fabricator QC Technician Requirements

- **PSE**
  - Minimum of PCI level 2 or higher qualification (or new NETTCP PS level 1 certification)

- **PCE**
  - Minimum of ACI level 2 or PCI level 1 (or NETTCP PS level 1 certification)
  - ACI level 1 is also acceptable for non-structural PCE
3. Agency Inspection: Pre Pour

- Minimal differences between agency practices.
- Maine and New Hampshire check-lists are the most comprehensive and user-friendly.
- A combined version of these is proposed to be used.
## 3. Agency Testing Recommendations

<table>
<thead>
<tr>
<th>Inspection Criteria</th>
<th>Element</th>
<th>Test Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>During Pour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>PSE</td>
<td>At least once per element and every 100 CY</td>
</tr>
<tr>
<td>Structural PCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Structural PCE</td>
<td></td>
<td>Once per continuous pour</td>
</tr>
<tr>
<td>Water/Cementitious</td>
<td>PSE</td>
<td>At least once per element and every 100 CY</td>
</tr>
<tr>
<td>Structural PCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Structural PCE</td>
<td></td>
<td>Once per continuous pour</td>
</tr>
<tr>
<td>Strength Cylinders</td>
<td>PSE</td>
<td>Once per element or every 100 CY; Number: Total 6 cylinders for permeability and strength testing</td>
</tr>
<tr>
<td>Structural PCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Structural PCE</td>
<td></td>
<td>Once per continuous pour; Number: Total 4 cylinders for strength testing</td>
</tr>
</tbody>
</table>
3. Agency Inspector Qualification

- **PSE**
  - Minimum of PCI level 2 or higher qualification (or NETTCP PS level 1 certification)

- **PCE**
  - Minimum of ACI level 2 or PCI level 1 (or NETTCP PS level 1 certification)
  - ACI level 1 is also acceptable for non-structural PCE
5. **Curing Requirements**

- Accelerated curing is the current state of the practice
- PSE and Structural PCE:
  - Controlling temperatures shall be those actually achieved within the concrete elements
  - Accelerated curing should started after concrete has attained initial set
  - Concrete temperature may be increased during the preset period at a rate of 10°F per hour or less
  - Total temperature gain during the preset period should be less than 40°F higher than the placement temperature or 104°F (lower of two)
  - A heat gain should not exceed 36°F per hour, measured in the concrete, provided the concrete has attained initial set
6. Logistics of Regionalized QA Process

- Need central entity to manage QAI pool
  - Central managing entity might be the solution (NETC or NETTCP like model)
  - ShiftPlanning or similar system (currently used by Vtrans) could be used to manage the pool and for purposes of scheduling

- Initial trials could be conducted using only consultant inspectors
  - Current range of rates are established and can be used for planning purposes
  - Focus initial trials for pre-stressed elements (simpler to unify QA process requirements)

- Technology could really help streamline the process
  - RFID tags + cloud-based storage
    - *Currently being explored by various agencies*
    - *Could serve as vehicle for real time data transfer*
Thank you for your attention

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