Introduction to Quality Assurance

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Quality in the Concrete Paving Process

Workshop Introduction
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Agenda

- Workshop Introduction
- Module 1: Quality Assurance Concepts
- Module 2: Concrete Materials
- Module 3: Concrete Properties and Testing
- Module 4: QC and Agency Acceptance
- Module 5: Pre-Paving and Mix Production
- Module 6: Paving
- Module 7: Utilizing Quality Concepts
- Module 8: Quality in Field Practice
Goal: Plant Seeds

- What do you do today?
- What are you striving to accomplish?
- What should the agency test and inspect?
- What should the contractor test and inspect?
- How should we accept concrete pavement?
- What new tools and technologies can you use to build better pavements?
Learning Objectives

By the end of this module, you will be able to:

- Understand the relationship between the Federal regulations, quality, variability, and the six building blocks of a Quality Assurance program
- Develop and/or evaluate a Quality Control Plan
- Think of changes to make back home
Why QA?

- Change in Agency Demographic
- Agency Personnel Levels
- Change in Contractor Demographic
- Rational Assessment of Pay
- Reduction in Product Variability
PCC vs. HMA
Sources of Variability

Material  Process  Sampling  Testing

Composite Variability
AASHO Road Test
Construction

- 1956 to 1958
- Highly controlled
- Specifications based on prevailing SHA practices
- Found that variability could not be eliminated
Six Building Blocks

- Agency Acceptance
- Contractor Quality Control
- Qualified Laboratories
- Qualified Personnel
- Independent Assurance
- Dispute Resolution
Qualified Laboratories & Accredited Laboratories

- State central labs must be accredited.
- Private labs conducting dispute or Independent Assurance testing must also be accredited.
- All other labs must be qualified through a state sponsored program.
Requirements for Personnel Qualification/Certification

- Recommended program guidelines:
  - Formal training; hands-on training
  - On-the-job training
  - Written and performance examinations
  - Periodic re-qualification (typically 2-5 years)
  - Process to remove personnel performing procedures incorrectly, falsifying statements or data
Independent Assurance

- Assessment of personnel proficiency and equipment
- Provides independent check on reliability of results of both partners
- Not used to make a determination of quality/acceptability of the product
Dispute Resolution

- Formal system designed to address significant differences between partners data of such magnitude to impact payment
- Not intended to address day to day issues
- Required (by FHWA) when contractor results used in acceptance decision
- Generally uses a “referee” lab
Testing Variability

- Inherent in the procedures and apparatus
- Influenced by the technicians
## Testing Variability

<table>
<thead>
<tr>
<th>Procedure</th>
<th>95% Lower Limit</th>
<th>Test Result</th>
<th>95% Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve analysis (% passing ½”)</td>
<td>24%</td>
<td>28%</td>
<td>32%</td>
</tr>
<tr>
<td>Slump</td>
<td>2”</td>
<td>2 ½”</td>
<td>3”</td>
</tr>
<tr>
<td>Air content</td>
<td>4.9%</td>
<td>5.5%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Rodded unit weight for aggregate</td>
<td>114.5 lb/ft³</td>
<td>120 lb/ft³</td>
<td>125.5 lb/ft³</td>
</tr>
<tr>
<td>Compressive strength</td>
<td>3,390 lb/in²</td>
<td>3,600 lb/in²</td>
<td>3,810 lb/in²</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>602 lb/in²</td>
<td>700 lb/in²</td>
<td>798 lb/in²</td>
</tr>
</tbody>
</table>
Testing Variability

These variability's assume...

- Qualified technicians
- Adherence to procedures
- Calibrated testing equipment
Six Building Blocks (23 CFR 637)

- Agency Acceptance-PWL motivates minimizing all variability (CPU 8)
- Contractor Quality Control-Material and Process
- Qualified Laboratories-Testing
- Qualified Personnel-Sampling and Testing
- Independent Assurance-Sampling and Testing
- Dispute Resolution-Sampling and Testing
Random Sampling (23 CFR 637.205(e))

- All samples used in the acceptance decision shall be random samples
  - All materials will have an equal probability of being sampled
  - Removes bias
  - Reduces potential for fraud

The tests on the first load in the morning are not random!
CORES R US
Random Sampling

- Simple Random Sampling
Stratified Random Sampling

- Stratified Random Sampling

[Diagram of stratified random sampling with sublots and sampling points]
Non-Random Sampling

- Used at start-up or when process adjustments are made
  - Example: adjusted air entrainment admixture dosage
  - Sample immediately and repeat testing to monitor the adjustment
  - Return to random sampling when desired results are consistent
  - What should the agency do?
Boston Central Artery/Tunnel Project
Quality Control Defined

**Quality Control** - The system used by a Contractor to monitor, assess, and adjust their production and placement processes to ensure that the final product will meet the specified level of quality.
Quality Control

- Uses **real time** feedback
- A good QC system:
  - Doesn’t try to accommodate Agency requirements
  - Implements QC procedures as standard practice
  - Isn’t just paperwork...it’s a mindset
Contractor Benefits

- **Competitive Advantage at the bidding table**
  - **Reduce construction costs**
    - QC costs range from $0.20-0.60/SY in one state
    - Remove and replace can cost 3 times the initial placement costs (upwards of $90/SY)
  - **Increase Incentives**
    - Know you will get full incentive
    - Use incentive to reduce bid amount
  - **Reduce Penalties**
    - Done right the first time
    - Reduced Re-Work
Quality Control

- Integrated throughout the organization
- Not just responsibility of QC personnel
- Quality can only be achieved by skilled and properly trained frontline workers
- Comprehensive, systematic, and continuous approach
- Proactive, not reactive
- Focus on preventing problems not finding them
- *Zero Defects philosophy*
Scope of Quality Control Activities

- Contractor’s QC system should address:
  - Materials production
  - Materials transportation and handling
  - Field placement procedures
  - Calibration and maintenance of equipment
  - Sampling, testing, and *inspection* to maintain each process “in control”
  - Use of QC information to make timely adjustments
Scope of Quality Control Activities

- **Inspection** is as important to Contractor QC as sampling and testing
- Necessary to minimize visually detectable problems
Project Quality Control Organization

- No “one-size fits all” QC organization structure
- Will vary depending on the size and complexity of the project
Quality Control Manager

- Establishing the Contractor’s QC system
- Preparing Quality Control Plans
- Managing QC Personnel
- Communicating routinely with Production Personnel
- Initiating Work suspension and corrective action when a process is found to be “out of control” or producing nonconforming materials
- Ensuring proper QC documentation and records
Production Facility
QC Technicians/Inspectors

- QC sampling, testing, and inspection at the Production Facility
- QC Test/Inspection Report Forms
- Providing feedback to Production Personnel based on QC inspection and testing results
Field QC Technicians/Inspectors

- QC sampling, testing, and inspection of field placement operations
- QC Test/Inspection Report Forms
- Feedback to Production Personnel (Foremen/Superintendents) and the QC Manager
QC Plan

- A *project specific* document prepared by the contractor which identifies QC procedures that will be used to maintain production and placement processes in control and meet the agency specification requirements.
Setting Expectations
Quality Control Plan

- Materials production processes
- Materials transportation and handling
- Field placement procedures
- Calibration and maintenance of equipment
- Activities (sampling, testing and inspection) to maintain each process in control
- Means to make timely adjustments and corrections
QC Plan Format and Contents

- Agency specifications normally identify minimum QC Plan requirements
- Project specific and reflect actual QC processes that will be applied
- Written in straightforward and plain speaking manner
- Comprehensive in the amount of information provided
QC Plan Format and Contents

- Quality Control Organization
  - Identify the specific QC Personnel and briefly describe their responsibilities and qualifications
    - QC Manager
    - Production Facility QC Technicians/Inspectors
    - QC Laboratory Personnel
    - Field QC Technicians/Inspectors
QC Plan Format and Contents

- Quality Control Laboratories
  - A list of all laboratories used to test materials along with their location
  - Lab Qualifications (CCRL, etc.)
  - Should include the name and points of contact for the Laboratory Manager
QC Plan Format and Contents

- Materials Control
  - Source of all constituent materials
  - Procedures for shipment, processing, storage and stockpiling
- Material Types and Properties
- Mix Designs
QC Plan Format and Contents

- Quality Control Inspection, Sampling & Testing
  - Lot and Sublot Sizes
  - Random Sampling Plan
  - Sample ID System
  - QC Inspection and Test Result Reporting
  - QC Sample Storage & Retention Procedures
QC Plan Format and Contents

- Production Facility
  - Schedule of Production Operations
  - Production Facilities & Equipment
  - Pre-Production & Production QC Activities (Inspection & Testing)
  - Production Facility Control Chart Examples
  - Procedures for Corrective Action of Non-Conforming Materials
  - Production QC Inspection Reporting
Quality in the Concrete Paving Process

QC Plan Format and Contents

- Field Management
  - Schedule of Field Placement Operations
  - QC activities for
    - Equipment
    - Materials Transportation & Delivery
    - Pre-Placement and Placement
  - Procedures for Corrective Action of Non-Conforming Materials
  - Field QC Inspection Reporting
Visual Inspection for Quality Control

- Visual inspection is also essential to achieving quality
- Observations and measurement of
  - Equipment
  - Environmental conditions
  - Materials
  - Workmanship
- Prevention based, not detection based
QC Inspection of Equipment

- Ensure that all equipment is in good working condition and is properly maintained
- Periodic calibration of equipment should also be performed
- Document prior to production
QC Inspection of Environmental Conditions

- Monitoring and measurements to ensure that the proper physical environment is being provided for:
  - Storage
  - Production
  - Placement
  - Curing of individual materials or products
Inspection by Production Personnel

- Contractors should strive to create a “Quality Culture” throughout the company.
- Personnel are aware of how their actions can affect the quality of the product.
- Contractors must invest in the continual education and training of their work force in order to maximize their involvement in Quality Control.
Inspection by Production Personnel

- Skilled Laborers and Foremen should be capable of identifying unacceptable materials prior to incorporation in the Work
  - Should take initial responsibility for accepting or rejecting it
  - Should always communicate their findings and proposed actions with their QC Inspectors
Analysis and Application of QC Test Results

- Timely analysis of QC data provides a powerful tool for QC Personnel to confirm whether process is “in control”
- Important that QC Personnel evaluate QC test data on a real-time basis
- Corrective actions are implemented and documented when necessary
QC Daily Diary

- QC Manager responsible
- Document all major activities related to the QC System each day
- Not intended to replicate or supersede individual Inspection Report Forms or Test Report Forms
- Serves as a summary record of key actions taken by QC Personnel
  - Summary of production or placement
  - Corrective Actions
QC Inspection Documentation

**Inspection Report Forms**
- Activities documented on daily basis
- Separate forms for production facility inspection and field placement inspection
- Outline or checkbox listing of key inspection items
- Note specific observations, measurements, or reviews of manufacturer’s materials certifications
- Document specific corrective actions or instructions
QC Inspection Documentation

- Inspection Report Forms
- Pre-Phase Checklists
  - Used prior to start of a major production or placement operation
  - Include all inspection components that have an impact on quality
Safety

- Quality construction is critical to providing safe transportation facilities

- July 2006 motorist fatality from partial collapse of tunnel ceiling on I-90 in Boston
30,000 Foot View of QC
Evolution in Our World

- 1991: ISTEA legislation offered states the option to act on behalf of FHWA
- MAP-21 mandated states act on behalf of FHWA off the National Highway System
- Design-Build accelerated the move to enhanced QC; states mandated QC systems on projects
Evolution in Our World

- DOT’s have seen the benefit of contractor quality systems
- Expanding D-B approach to traditional D-B-B projects
- Opportunities for contractors
- CMGC offers the opportunity to continue the evolution
QC Example

- Smoothness testing shows a must-grind bump from the previous day’s paving
QC Example

- Should we care what caused the bump?
QC Example

- What information would help us determine the cause(s) of the bump?
QC Example

- UNFORTUNATELY ...
- Contractor’s QC plan states:
  - “Materials, equipment and methods used to construct concrete pavement will conform to Section 501 of the specifications”
  - “Quality control testing will be performed in accordance with Section 501.14 of the specifications”
QC Example

WHAT IF ...

Contractor’s QC plan states:

• 20’ straightedge advanced at 10’ increments

• Paving foreman will maintain a log of all “events” indexed by station

• Smoothness test results will be provided to the paving foreman for analysis and approval within one hour of testing
## QC Example

- **Example of a foreman’s diary**

<table>
<thead>
<tr>
<th>Sta.</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>348+50</td>
<td>start day, paver out of super transition, tangent section now</td>
</tr>
<tr>
<td>349+00</td>
<td>ADJ paver on right side so that I could get the 12&quot; I need on profile, crank down one</td>
</tr>
<tr>
<td>349+50</td>
<td>paver stopped because of TBI</td>
</tr>
<tr>
<td>349+50</td>
<td>XXXXX hit me - on right side with his straightedge</td>
</tr>
<tr>
<td>350+00</td>
<td>RF steering sensor wand hit dowel bar bundle</td>
</tr>
<tr>
<td>350+50</td>
<td>crank down one on right side</td>
</tr>
<tr>
<td>353+00</td>
<td>paver was over loaded</td>
</tr>
<tr>
<td>354+00</td>
<td>paver stopped to fuel</td>
</tr>
<tr>
<td>354+00</td>
<td>roll size of OCB 1' in</td>
</tr>
<tr>
<td>354+50</td>
<td>XXXXX speeded up paver a bit 8' 4&quot; fpm</td>
</tr>
<tr>
<td>354+85</td>
<td>paver stopped</td>
</tr>
<tr>
<td>355+50</td>
<td>mud box is about half full only</td>
</tr>
</tbody>
</table>
QC Example

- What caused the bump?
Agency Monitoring QC Activities

- Periodic visual observation of QC inspection, sampling, and testing
- Review of QC records/documents
- Provide feedback to contractor’s personnel
Agency Response to Inadequate Quality Control

- Specifications:
  - Direct contractor to suspend operations
  - Withhold payment to the contractor
  - Withhold payment for contractor QC activity

- PM/RE should be aware of contract provisions and apply them
Maine...The Way Life Should Be

- QC Plan approved by MaineDOT
- Specific and on par with Specifications
- Penalties for violations
  - 1\textsuperscript{st}: Warning
  - 2\textsuperscript{nd}: 1% of items covered in QC Plan
  - 3\textsuperscript{rd}: Additional 2% of items covered in QC Plan
Conclusions

- Federal quality regulations aim to reduce variability
- QC continues to evolve
- Inspection is a mandatory part of concrete QC
- QC Plans must grow beyond what we have traditionally used

- Thank You!