Quality Assurance

BEST PRACTICES WORKSHOP
Outline

• What is quality?
• Who cares?
• The Agency
• The Contractor
• Measurement
Defining Quality

• Simple Definition (Philip Crosby)
  ➢ Quality: “Conformance to requirements”
  ➢ Quality is defined by our customers

• QA = “Making sure the quality of a product is what it should be”
Why is Quality Important?

• Is 99.9% “good enough?”
  ➢ 1 hour of unsafe drinking water every month
  ➢ 2 long or short landings at every American airport each day
  ➢ 500 incorrect surgical operations each week
  ➢ 3,000 newborns accidentally falling from the hands of nurses or doctors each year
  ➢ 22,000 checks deducted from the wrong bank account each hour
Why Should I Care

• Money!
  ➢ Penalties vs. Incentives
Why Should I Care

• Better working environment
  ➢ Project partners are qualified
  ➢ Contractor knows how the Agency will accept/pay for the product
  ➢ QC Plans remove some of the daily stress
• Product you paid for
Trick Question

• How do the following people affect quality?
  ➢ Designer/Specifier
  ➢ Agency Inspector
  ➢ QC Technician
  ➢ Loader Operator at the concrete plant
  ➢ Truck Driver
  ➢ Paver Operator
  ➢ Concrete Finisher
  ➢ Texture/Cure Machine Operator
Core Elements of an Agency QA Program

Quality Assurance

Quality Control

Agency Acceptance
Acceptance

• Agency must carry out all acceptance activities
• Agency must independently inspect and test for Acceptance
• Contractor QC data may be used in Agency Acceptance
Building Blocks

- Agency Acceptance – Measuring the things that matter
- Contractor Quality Control - Material and Process

- Qualified Laboratories - Testing
- Qualified Personnel - Sampling and Testing
- Independent Assurance - Sampling and Testing
- Dispute Resolution - Sampling and Testing
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
Qualified Laboratories & Accredited Laboratories

• All state central labs must be **accredited**.
• All private labs conducting dispute or Independent Assurance testing must also be **accredited**.
• All other labs must be **qualified** through a state sponsored program.
Independent Assurance

• Provides an assessment of personnel proficiency and equipment
• Provides independent check on reliability of results of both partners
• Uses split sample
• Not used to make a determination of quality/acceptability of the product
Function of 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
The Contractor

• Contractor’s QC system should address:
  ➢ Materials production processes
  ➢ Materials transportation and handling
  ➢ Field placement procedures
  ➢ Calibration and maintenance of equipment
  ➢ Watching the process
  ➢ Fixing the process
The Contractor

- Corporate culture
  - Quality culture has to start at the top
  - Failures are opportunities to learn
  - Processes should be well defined
  - Staff have to have authority
The Contractor

• Training
  • All levels have to understand their jobs and the systems they are working with
  • Reduces risk
  • Reduces margins
Quality Control

- Aim of QC is assure contractor that the mixture is going to be accepted
- A QC plan should include:
  - Unit weight
  - Calorimetry
  - Maturity
  - Strength development
  - Air void stability
Quality Measurement Tools

• Two principal tools used to measure conformance with requirements:
  ➢ Inspection
  ➢ Testing
Inspection

• Equipment
• Environmental Conditions
• Materials
• Product Workmanship
• Three criteria:
  ➢ Quality Characteristics (What do we want?)
  ➢ Quality Measures (How do I measure it?)
  ➢ Quality Limits (How much is enough?)
QA Principles

• Types of Tests
  ➢ Random Samples
    ➢ For compliance with specifications
    ➢ No others count for compliance
  ➢ Process control Test
    ➢ Not Random
    ➢ Contractors use when needed
      – Change in process or material
Innovative Test Methods

• Better test methods (for those critical properties)
  ➢ VKelly
  ➢ Box
  ➢ Resistivity / Formation factor
  ➢ Bucket / Sorptivity
  ➢ Dual ring
  ➢ SAM
Point of Acceptance

- The contractor’s concrete until the agency tests it
- Are you testing the final product?

Contactor’s concrete | Agency’s concrete

At the plant | In front of the paver | Behind the paver

Contractor's concrete | Common point of acceptance | This is what counts!

Haul | Through the paver | Lose air | Lose air
• Kelly ball test
  ➢ Developed in the 1950s in US
  ➢ Standardized in California DOT test
  ➢ Comparable to slump test
• Measure initial slump (initial penetration)
• Start vibrator for 36 seconds at 8000 vpm
• Record depth every 6 seconds
• Repeat
• Plot on root time
• Calculate slope = VKelly Index
**Box Test**

- A test that examines:
  - Response to vibration
  - Filling ability of the grout (avoid internal voids)
  - Ability of the concrete to hold an edge

Image: Oklahoma Transportation Center
Box Test

- Add 9.5” of unconsolidated concrete to the box
- Insert 1” diameter stinger vibrator (8000 vpm) into the center of the box over a three count and then remove over a three count
The edges of the box are then removed and inspected for honey combing and edge slump.

<table>
<thead>
<tr>
<th></th>
<th>Over 50% overall surface voids.</th>
<th>30-50% overall surface voids.</th>
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<tbody>
<tr>
<td>4</td>
<td>10-30% overall surface voids.</td>
<td>Less than 10% overall surface voids.</td>
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Super Air Meter

- Reports air content and SAM number
- SAM number correlates well with freeze-thaw testing

Images: Tyler Ley (left) and National CP Tech Center (right)
Formation Factor

- The resistivity test gives you a single number that is an indication of a lot of different things -
  - Ionic concentration of the pore solution
  - Formation Factor
  - Moisture
  - Temperature
  - Geometry
  - Curing conditions
The Bucket Test

- Cast concrete and keep sealed for 14 days
- Measure the cylinder mass after demolding
- Place three concrete cylinders in lime water
- Measure their mass at 5 days
- Measure their mass again every 10 days until they are 60 days old
- Oven dry cylinder and take mass
- Vacuum saturate cylinder and take mass
- Calculate the time to critical degree of saturation.
This ring can measure both expansion and contraction.

As the concrete shrinks the ring can measure the strains that occur.

We force a temperature gradient in the concrete and make it crack and compare that to 60% of the split tension capacity after 7 days.
Smoothness

Inertial Profilers (acceptance)
Smoothness

- Increased Smoothness
  
  Reduced dynamic loading
  
  Extended pavement life

- Improved by:
  - Providing pad line
  - Stringline maintenance
  - Use stringless paving
  - Concrete mixture
  - Paving process
  - Sawing and curing
Load Transfer

- MIT SCAN-2
- Numerically and visually
- As soon as you can walk on it
- Need to cut the tie wires
- Non-metallic tie wires
Thickness Measurement

- MIT-SCAN-T2
- Non-destructive
- Rapid
- Independent of the base material
- Independent of the maturity of concrete
- High accuracy
  - Within ± 0.1 inch of core thickness
QA Principle

- $N = 1$
Quality Processes Address Variability

Material  Process  Sampling  Testing

Composite Variability
Control Charts

- Used to plot and monitor consecutive test results
- Results can be tracked against a process target/limits
- Can help to identify whether the process is in control
- May indicate that adjustments are necessary
Questions?