

Quality Assurance

BEST PRACTICES WORKSHOP



U.S. Department of Transportation
Federal Highway Administration

National Concrete Pavement
Technology Center



IOWA STATE UNIVERSITY
Institute for Transportation

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



CONTRACTOR

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



OWNER

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

**Independent Assurance
Dispute Resolution
Qualified Labs
Qualified Personnel**

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
Dispute Resolution
Qualified Labs
Qualified Personnel**

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
Dispute Resolution
Qualified Labs
Qualified Personnel

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**

Independent Assurance
Dispute Resolution
Qualified Labs
Qualified Personnel

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

Independent Assurance
Dispute Resolution
Qualified Labs
Qualified Personnel

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

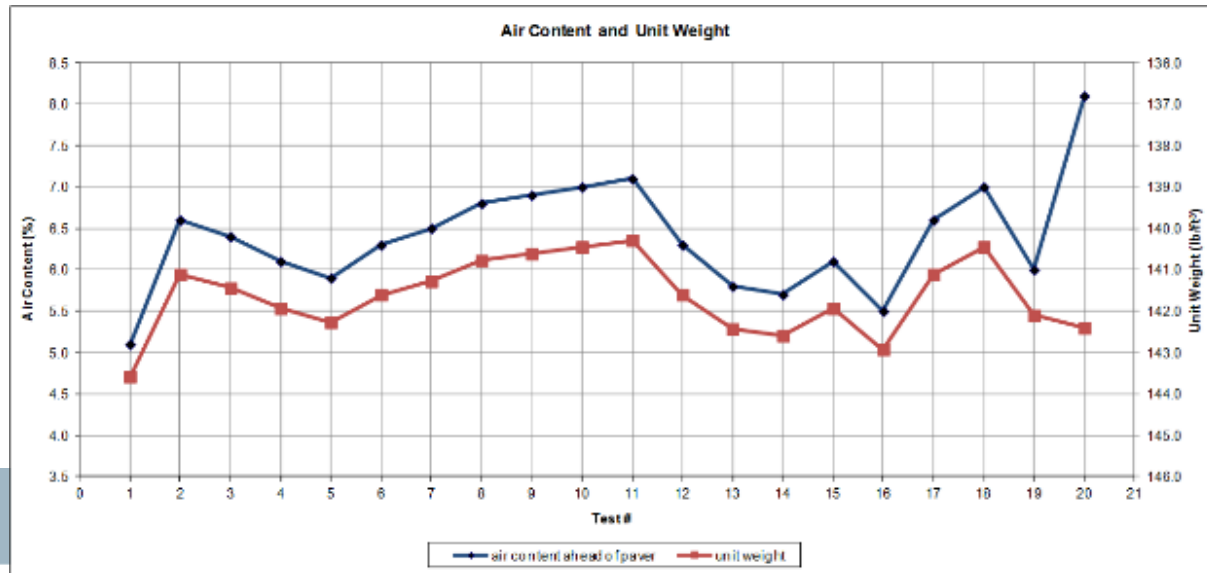


The Contractor

- 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



Testing

- 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?



At the plant

In front of the paver

Behind the paver



Haul

Lose air



Through the paver

Lose air



Contractor's concrete

Common point of acceptance

This is what counts!

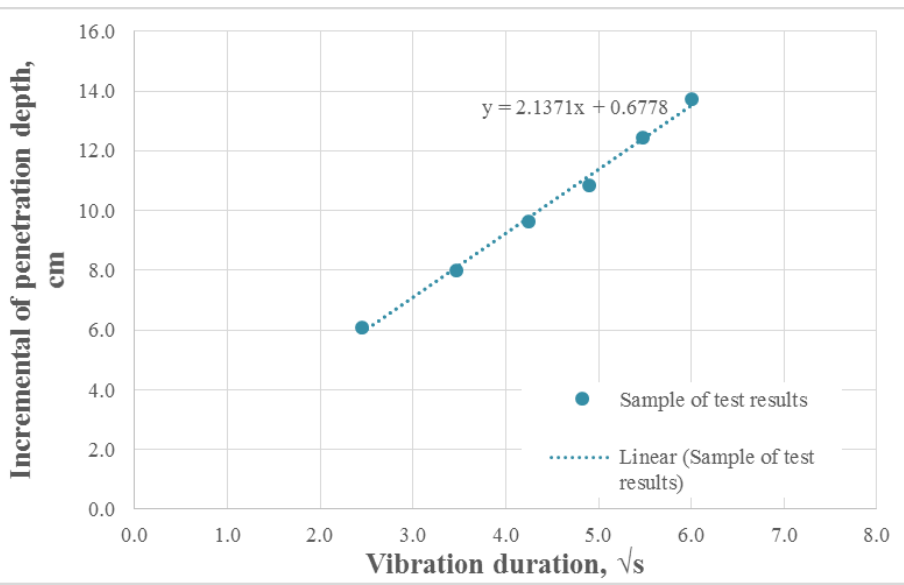
VKelly

- Kelly ball test
 - Developed in the 1950s in US
 - Standardized in California DOT test
 - Comparable to slump test



VKelly

- 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

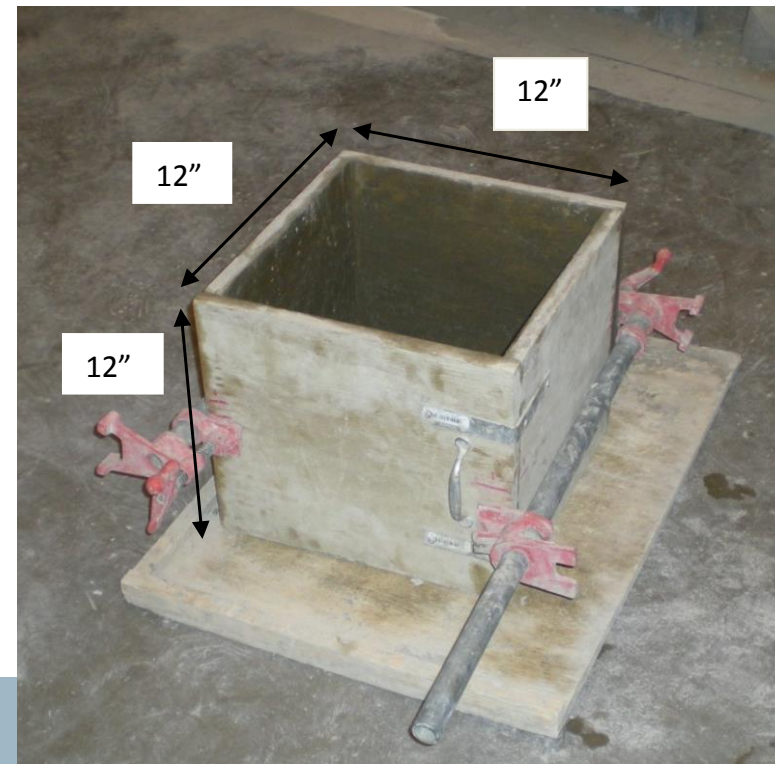


Images: National CP Tech Center



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



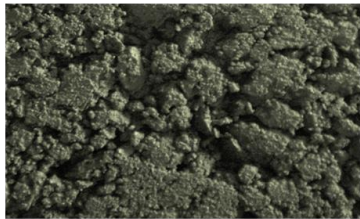
Box Test

- 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



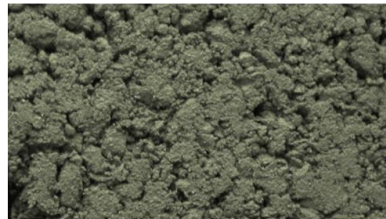
Box Test

- The edges of the box are then removed and inspected for honey combing and edge slump



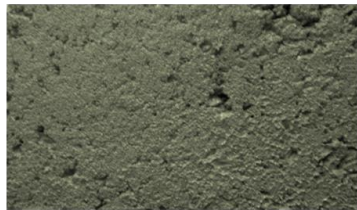
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Over 50% overall surface voids.



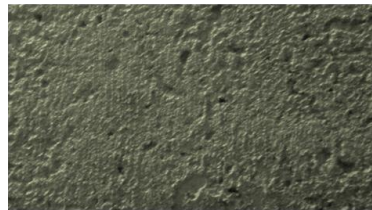
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30-50% overall surface voids.



2

10-30% overall surface voids.



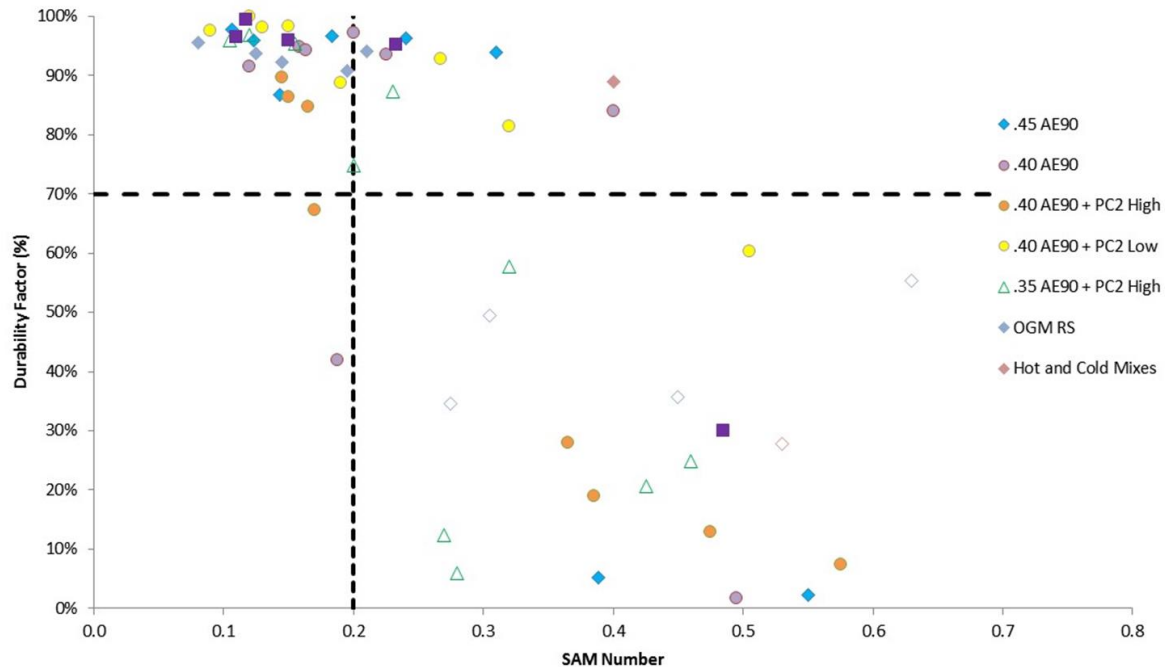
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Less than 10% overall surface voids.



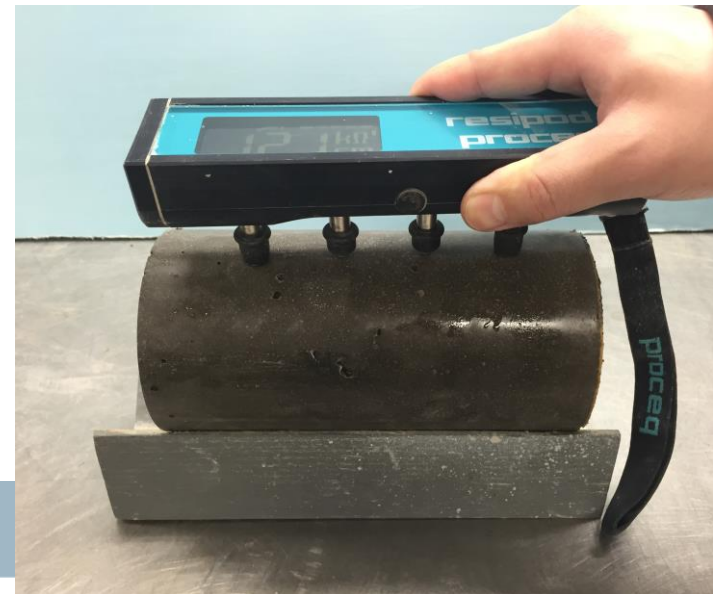
Super Air Meter

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



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

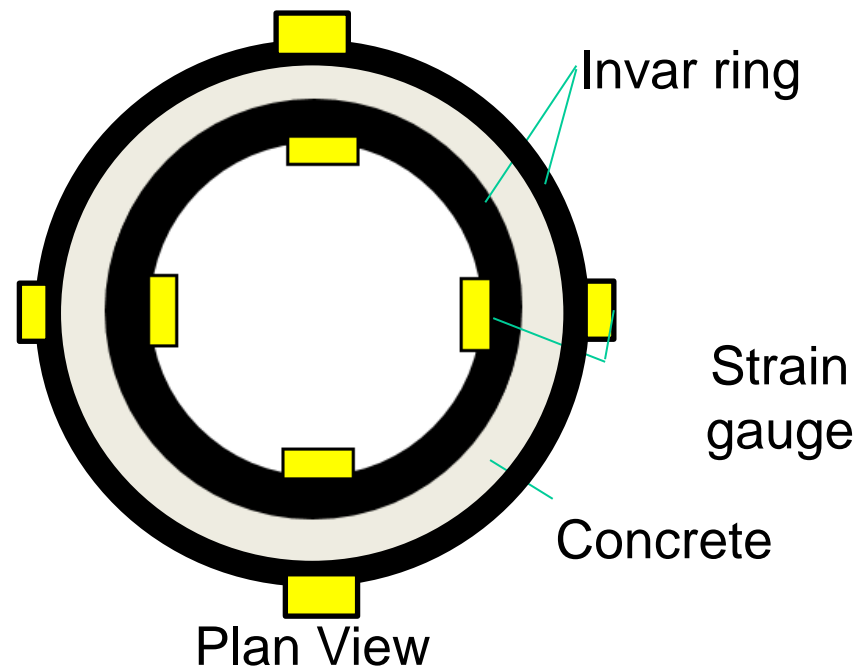


The Bucket Test

- 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.



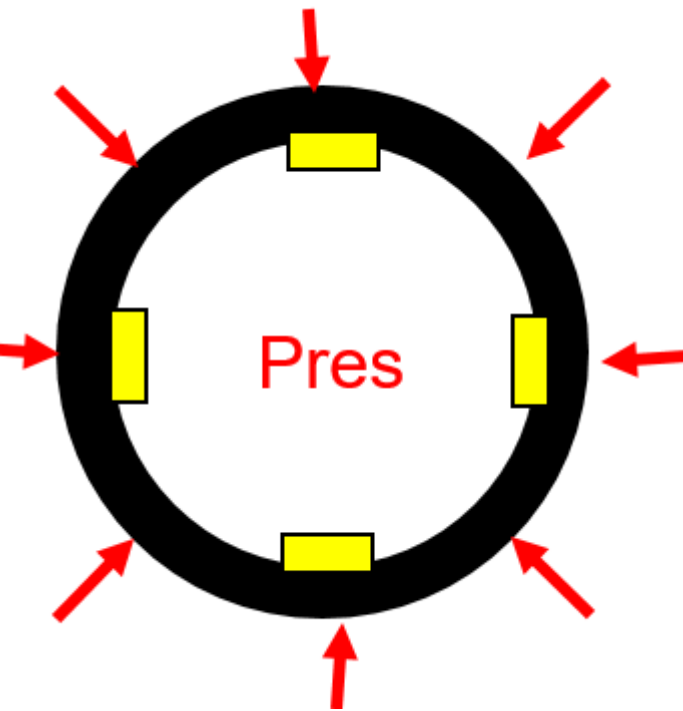
Dual Ring Test



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



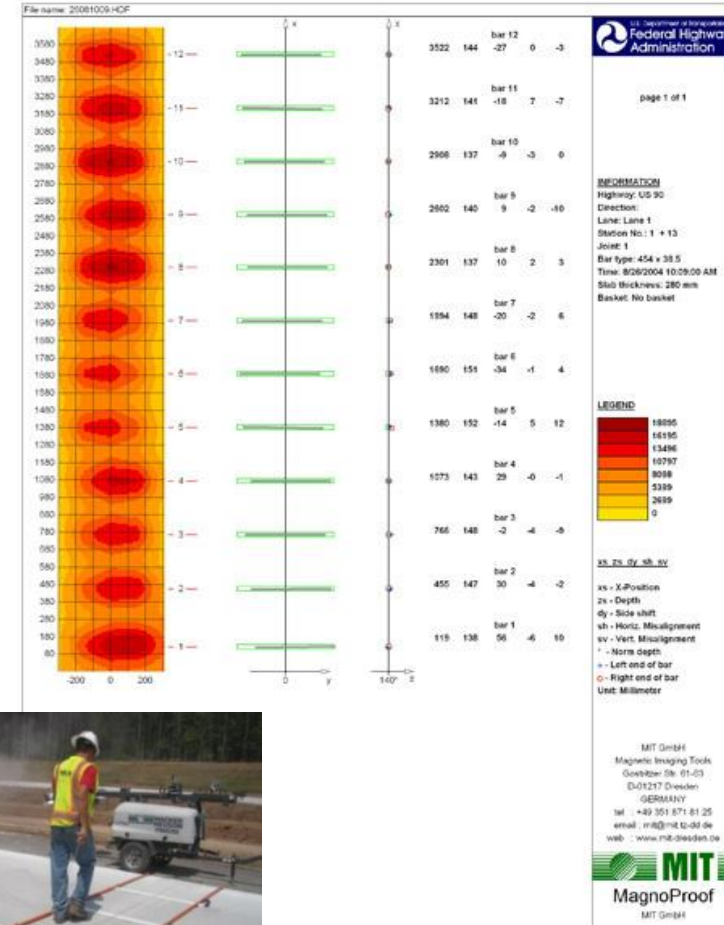
Extended pavement life

- 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

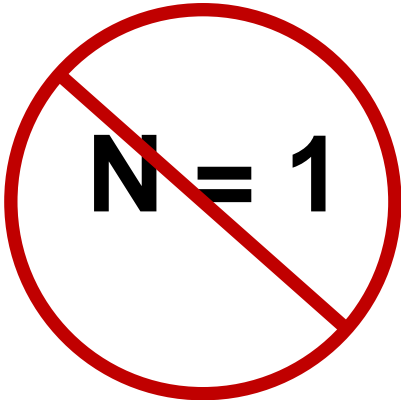


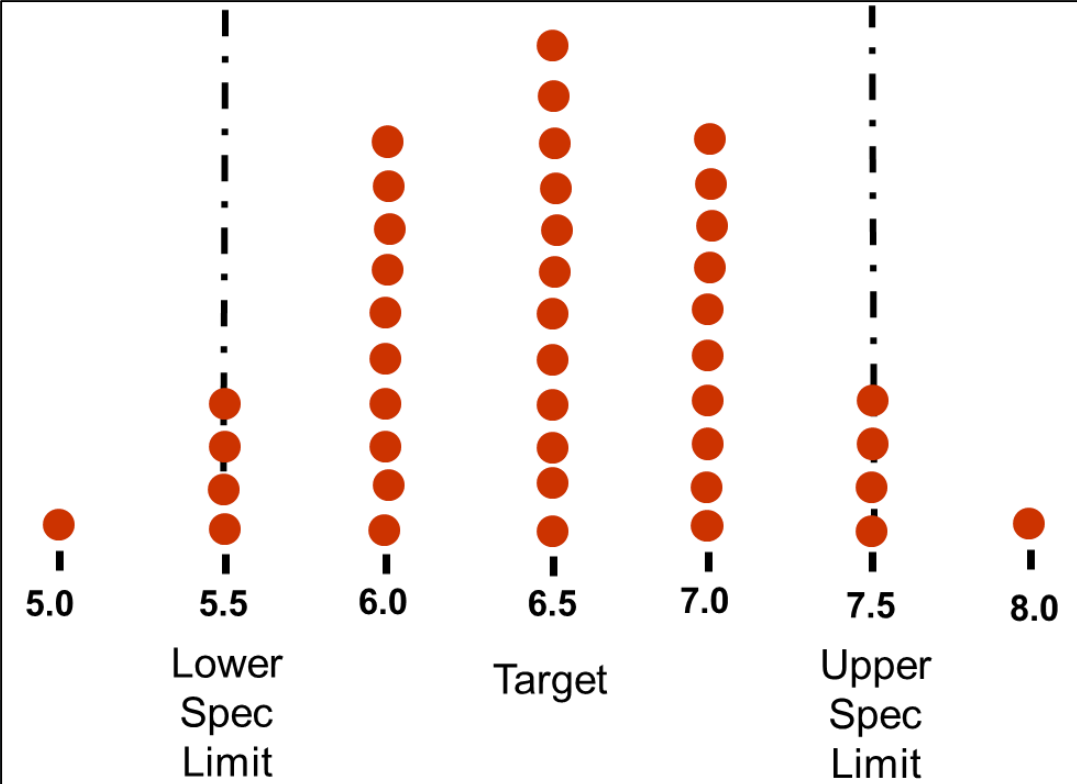
Thickness Measurement

- 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



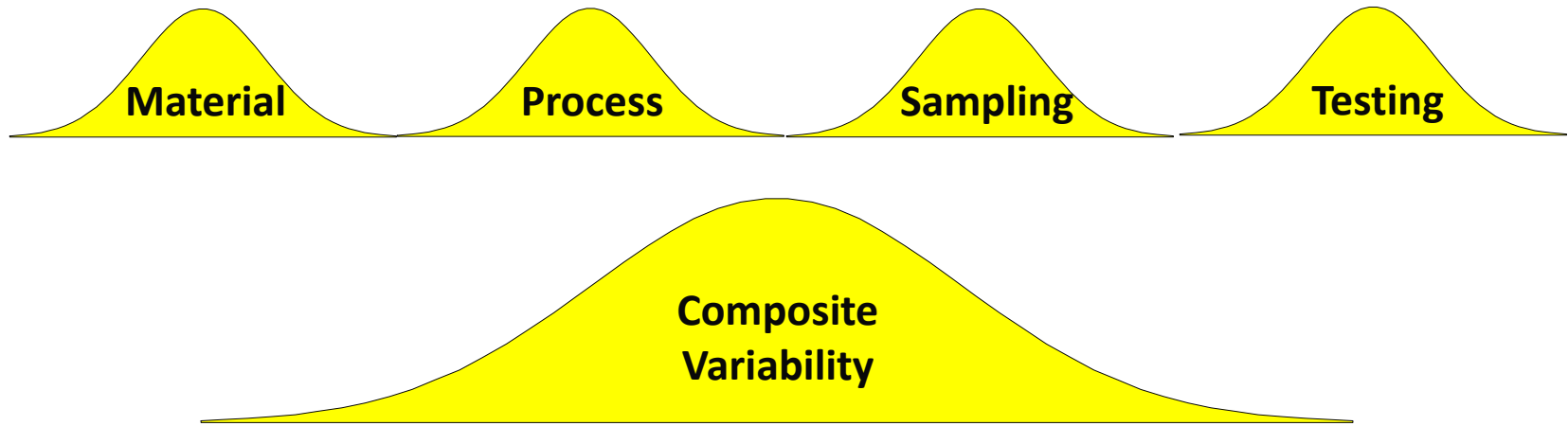
Process



Sampling

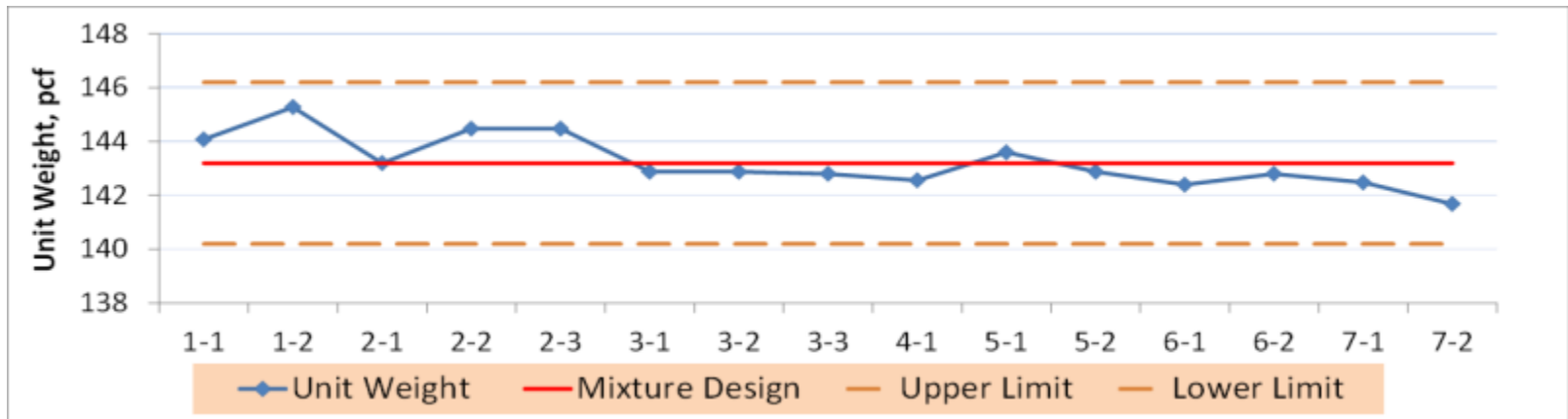


Testing



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?