Quality in the Concrete Paving Process

Workshop Introduction
Instructors

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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
What is this Workshop about?

- Common Sense
- Tools
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?
Utilizing Quality Concepts

Material  Process  Sampling  Testing

Composite Variability
Learning Objectives

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

- Describe how PWL is used to assess quality
- Understand the impact of variability
- Understand the basics of control charts
- Understand the information provided by a heat signature plot
- Recognize the time savings by using the maturity for opening strength
Normal Distribution

- Properly obtained statistical sample for an entire lot of most construction material will form a Normal Distribution Curve
68 – 95 – 99.7 Rule

- This Empirical Rule states that:
  - 68% of all possible samples are clustered about the mean within ± 1 standard deviation
  - 95.5% are within ± 2 standard deviations
  - 99.7% are within ± 3 standard deviations
Testing Targets and Limits Based on Normal Distribution

- Specifications normally identify targets and/or limits for individual quality characteristics.

- Specification limits should be based on the principle of normal distribution.
Standard Deviation

- Sample standard deviation ($s$)

$$s = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n - 1}}$$
PWL

- Using the sample data, with its mean and standard deviation, we can determine the quality level of the sample.
PWL

- Estimates the percentage of material within specification limits
  - Assumes normal distribution
  - Area equals 1.0 or 100%
PWL

- Efficiently captures mean and standard deviation in one quality measure
Single Specification PWL

$\text{PWL}_L$ or $\text{PWL}_U$

LSL or USL

$\bar{X}$
Double Specification PWL

Double Specification PWL

\[ \text{Double Specification PWL} = \text{PWL}_L + \text{PWL}_U - 100 \]
Estimating PWL in Four Steps

1. Obtain random samples
2. Compute
   • Mean ( \( \bar{x} \) )
   • Standard deviation (s)
3. Compute quality index (Q)
4. Convert Q to “estimated” PWL
Compute Q

\[ Q_U = \frac{USL - \bar{X}}{s} \]

\[ Q_L = \frac{\bar{X} - LSL}{s} \]
Convert Q to PWL

- Lookup estimated PWL from Q for a specified number of samples (n)

\[ Q_L \rightarrow PWL_L \]
Convert Q to PWL

- Lookup estimated PWL from Q for a specified number of samples (n)

\[ Q_U \rightarrow PWL_U \]
Convert Q to PWL

\[ \text{PWL}_L + \text{PWL}_U - 100 = \text{PWL} \]
Approaches to Using Pay Factors

- Quality Assurance specifications typically use a pay factor formula to determine pay factors.
- Under each approach, the pay factors are directly related to the PWL.
Using PWL to Compute Pay Factors

- Pay Factors:
  - Recoup losses expected from poor quality work
  - Reward increased performance from increases in product consistency
Pay Factor Formula

- A pay factor formula presents a mathematical equation that typically derives a linear schedule of pay from the PWL.
- AASHTO provides a recommended equation:
  \[ \text{Pay Factor (PF)} = 0.55 + 0.5 \times \text{(PWL)} \]
  (PWL is expressed as a decimal value in this equation)
Maine Example

- Data analysis of materials testing from 1978-1998
- Per cent “passing” tests ranged from 87%-92% every year
- Confirms that our industry, without incentives, operates around 90 PWL
Why Incentives?

- Motivate contractors to improve quality
  - Fairness
  - Positive approach
  - Factor into bidding
- Differentiate contractors that produce “desirable” and “undesirable” quality work
- When incentives are included, they should be sufficient to encourage contractor innovation
Quality in the Concrete Paving Process

Payment Plan with 5% Incentive

Pay Factor (RF) = 0.5PWL + 55

AQL

RQL

Estimated PWL
Payment Plan with Incentive

AQL=90

Estimated PWL

Pay factors

Pay
Disincentive
Pay
Incentive
Payment Plan without Incentive

Pay Factor (PF) calculated as:

\[ PF = 0.5 \times PWL + 55 \]

AQL

Estimated PWL

PF = 100
Payment Plan without Incentive

AQL=90
Payment Plan without Incentive

AQL=90

Estimated PWL

Pay Disincentive

Pay factors
Sources of Variability

Material  Process  Sampling  Testing

Material  Process  Sampling  Testing

Composite Variability
Validity of Sampling Data

- Required for Statistical analysis:
  1. “Multiple” (n > 3) samples are used
  2. All samples are “Randomly” obtained
  3. Material is produced and samples are obtained under “Controlled Conditions”
A technician randomly obtains one sample of concrete from a 50 yard lot and determines the air content of this sample.

- How well does this individual sample result represent the probable air content for every material sample from the entire lot of concrete?
Air Content (%)
The same technician now randomly obtains two separate samples of n = 5 from the same 50 yard lot of concrete and determines the air content of each sample.

- Which of the two samples is more representative of the probable air content of the entire lot of concrete??
Air Content (%) Sample # 1

<table>
<thead>
<tr>
<th>Lower Spec Limit</th>
<th>Target</th>
<th>Upper Spec Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>6.0</td>
<td>6.5</td>
<td>7.0</td>
</tr>
<tr>
<td>7.0</td>
<td>7.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>
Air Content (%) Sample # 2

- Lower Spec Limit: 5.0
- Target: 6.0, 6.5
- Upper Spec Limit: 7.0
One way to obtain a more complete picture of the true variability of the air content of the 50 yard lot of concrete would be to test one sample from each of the 50 yards (creating 50 sublots)
True Variability

<table>
<thead>
<tr>
<th>Air Content (%)</th>
<th>Lower Spec Limit</th>
<th>Target</th>
<th>Upper Spec Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
True Variability

<table>
<thead>
<tr>
<th>Air Content (%)</th>
<th>Lower Spec Limit</th>
<th>Target</th>
<th>Upper Spec Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td></td>
<td>6.5</td>
<td>8.0</td>
</tr>
<tr>
<td>5.5</td>
<td></td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Quality in the Concrete Paving Process

True Variability

Air Content (%)

Lower Spec Limit: 5.0
Target: 6.5
Upper Spec Limit: 8.0
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>
Air Content Testing Example

- Specified air content – 5.0% to 6.5%
- Two tests from the same wheelbarrow of concrete
  - Contractor test result – 4.9%
  - Agency test result – 5.5%
- What is the air content?
- What would happen if the test results are reversed?
Air Content Testing Example

- Two testers conducted air content testing
- Used concrete from same wheel barrow
- Consistent pattern of 0.5% difference in test results
Air Content Testing Example

Tester 1
- Meter 1 => 4.5%
- Meter 2 => 4.5%

Tester 2
- Meter 2 => 5.0%
- Meter 1 => 5.0%
Air Content Testing Example

Tester 1
- Plate => 5.2%
- Bar => 5.9%

Tester 2
- Plate => 5.1%
- Bar => 6.1%
Statistical Process Control (SPC)

- Monitor QC measurements and react
  - Concentrate on identifying change
  - Do not focus on specification limits
  - Changes in materials and/or processes (unusual test results)
Chance Causes vs. Assignable Causes

- Construction materials are subject to a certain degree of variability, stemming from two primary sources:

**Chance cause** –
A source of variation that is inherent in any production process and which cannot be eliminated as it is due to random, expected causes.

**Assignable cause** –
An identifiable, specific cause of variation in a given process or measurement. A cause of variation that is not random and does not occur by chance.
Control Chart Basics

- Control charts are process and contractor specific
- Average of test results plotted as the centerline
- Upper and lower control limits
  - Usually plotted at 3 times the standard deviation (3s) of representative test data
  - Define the limits of chance cause variability

![Unit Weight Control Chart](chart.png)
Control Chart Basics

- 3s limits are not specification limits!
- Reflect the voice of the process so that we can identify assignable cause variability
Control Chart Basics

- Revise 3s limits when process changes result in changes to the chance cause variability
  - 3s limits that are too tight ⇒ chasing phantom assignable cause variability
  - 3s limits that are too loose ⇒ mask assignable cause variability

![Unit Weight Control Chart](image-url)
Control Chart Basics

- Recognizing assignable cause variability
  A. One test result is outside of the 3s limits
Control Chart Basics

- Recognizing assignable cause variability

B. Six consecutive test results are all increasing or decreasing
Control Chart Basics

- Recognizing assignable cause variability

C. Nine consecutive test results are on the same side of the average value
Control Chart Basics

- Recognizing assignable cause variability

D. Fourteen consecutive test results are alternating up and down
Control Charts

- Control charts do not
  - Eliminate variability
  - Tell you where your problem lies
  - Tell you how to correct the problem

- Some control charts
  - Help distinguish between the inherent chance causes of variability and assignable causes
Limits

Air Content Ahead of the paver
Dual Axis Plot Example

- Air content plotted on the left vertical axis
- Plot unit weight on the right vertical axis
Dual Axis Plot Example

- Unit weight data varies as expected with the air content
- Except for test #20
Quality in Field Practice
Data from Arizona DOT Project

- Mobile Concrete Lab
  - Tested from paving on L303 section between Thomas to Camelback
  - Testing from July 9 to July 19
  - This Module presents test data
  - Review principles discussed yesterday and this morning

- Agency Acceptance Goal
  - Does the concrete match the mix design?

- QC Goal
  - Has the concrete changed?
Concrete Mixture

**Mixture Design**
- Cement Type II (low alkali), Class F Fly Ash
- Night time paving
- High temperatures (chillers to cool concrete)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Weight (lbs)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>451</td>
<td>Cemex, Victorville, CA</td>
</tr>
<tr>
<td>Fly Ash, Class F</td>
<td>113</td>
<td>SRMG, Cholla, AZ</td>
</tr>
<tr>
<td>Coarse Aggregate (#4), lbs</td>
<td>509</td>
<td>West Valley, AZ</td>
</tr>
<tr>
<td>Intermediate Aggregate (#57), lbs</td>
<td>1524</td>
<td>West Valley, AZ</td>
</tr>
<tr>
<td>Fine Aggregate, lbs</td>
<td>1180</td>
<td>West Valley, AZ</td>
</tr>
<tr>
<td>Water</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Air Content, %</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

Total Cementitious Content: 564lbs
Fly Ash: 20%
## Data from an Example Project

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample Day</th>
<th>Sample IDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/24/2013</td>
<td>1</td>
<td>1-1, 1-2, 1-3, 1-4</td>
</tr>
<tr>
<td>9/25/2013</td>
<td>2</td>
<td>2-1, 2-2, 2-3, 2-4, 2-5</td>
</tr>
<tr>
<td>9/26/2013</td>
<td>3</td>
<td>3-1, 3-2, 3-3, 3-4, 3-5</td>
</tr>
<tr>
<td>9/27/2013</td>
<td>4</td>
<td>4-1, 4-2, 4-3, 4-4</td>
</tr>
<tr>
<td>9/28/2013</td>
<td>5</td>
<td>5-1, 5-2, 5-3</td>
</tr>
</tbody>
</table>
Gradation

- Optimized combined gradation
  - Workability
  - Durability
  - Dimensional stability
Shilstone Coarseness Factor Chart

- Workability

- IV - too many fines
- III - MSA < 0.5"
- II - ideal
- V - rocky mixes
- I - segregation
0.45 Power Chart

Density

0.45 Power Chart

Sieve Size Raised to 0.45 Power

Combined Percent Passing (%)

Maximum Density Line

Combined % Passing

No. 57 Sand

Sand
Percent of Aggregate Retained on Each Sieve

- Gaps in the gradation
Shilstone Coarseness Factor Chart

- Workability

Note: From one sample tested by FDOT
Quality in the Concrete Paving Process

0.45 Power Chart

- Density

![Diagram](image_url)

**0.45 Power Chart**

- **Density**

![Graph](graph_url)

- **Maximum Density Line**
- **JMF (Combined % Passing)**

**Combined Percent Passing (%)**

**Sieve Size Raised to 0.45 Power**

U.S. Department of Transportation
Federal Highway Administration

Module 8- 71
Percent of Aggregate Retained on Each Sieve

- Gaps in the gradation
Shilstone Coarseness Factor Chart

- Workability

- Segregation

IV - too many fines

III - MSA < 0.5"

II - ideal

I - segregation

V - rocky mixes
Quality in the Concrete Paving Process

0.45 Power Chart

- Density

![Graph of 0.45 Power Chart]

- Maximum Density Line
- Combined % Passing

<table>
<thead>
<tr>
<th>Sieve Size Raised to 0.45 Power</th>
<th>Combined Percent Passing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#200</td>
<td>0</td>
</tr>
<tr>
<td>#30</td>
<td>10</td>
</tr>
<tr>
<td>#8</td>
<td>20</td>
</tr>
<tr>
<td>#4</td>
<td>30</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>40</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>50</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>60</td>
</tr>
<tr>
<td>1&quot;</td>
<td>70</td>
</tr>
</tbody>
</table>

0.45 Power Chart

U.S. Department of Transportation
Federal Highway Administration
Module 8-74
Percent of Aggregate Retained on Each Sieve

- Gaps in the gradation
Monitor Concrete Consistency

- Look for changes
- Use different tests to help identify the source of the change
  - Water
  - Air
  - Temperature
  - Cementitious
- Establish limits of change
Quality in the Concrete Paving Process

**Slump**

- Measure of consistency
- Quick and easy test
- Very consistent concrete

![Graph showing slump measurement](image)

- Slump, in
- Average Slump
- Max Slump
Air Content

- Air content
  - Target air content
  - Limited Variability observed
  - Total air is different from the air void system
Unit Weight

- Variability
  - Uniformity
    - Batching tolerances
  - Air and water content
  - Simple and easy to run

<table>
<thead>
<tr>
<th>Unit Weight, pcf</th>
<th>Average</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>143</td>
<td>144</td>
<td>145</td>
<td>146</td>
</tr>
</tbody>
</table>
Air/Unit Weight

- Normally they will run parallel
  - Unit weight changes if air content changes
  - Unit weight changes if water (slump) changes

- When they diverge
  - Change in materials or proportions
MCL Observations

- Air content
  - Variability observed
MCL Observations

- **Unit weight**
  - Variability observed
MCL Observations

- Air content and unit weight
  - Vary together
  - Unit weight changes appear to be from air content only (likely changes in water)
Quality in the Concrete Paving Process

Slump

- Measure of consistency
- Quick and easy
- Used for QC

![Slump Measurements at the plant](image)
Slump

- Measure of consistency
- Quick and easy
- Used for QC

Slump Measurements at the plant
Air Content

- Air content
  - Target air content
  - Total air is different from the air void system

![Graph showing air content by sample ID]
Unit Weight

- **Variability**
  - **Uniformity**
    - Batching tolerances-Normally within 3 lbs ±
  - **Air Content and Water content**
  - **Design Unit Weight**
Air/Unit Weight

- Normally they will run parallel
  - Unit weight changes if air content changes
  - Unit weight changes if water (slump) changes
- When they diverge
  - Change in materials or proportions
Unit Weight vs. Air Content Before Paver

- Contractor QC Data
Microwave Water Content

Water Cementitious Ratio

Mix Design Target

Average w/cm ratio

Sample ID

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Module 8-91
Microwave Water Content

Water Cementitious Ratio

Mix Design Target

W/Cm Ratio

Mix Design Target

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Federal Highway Administration
Concrete Temperature

- Is the concrete below the specified upper limit?
- Affects hydration rate
  - Workability
  - Compatibility

---

**Graph**

- **Temperature, F**
- **Sample ID**
- **Concrete Temp, F**
- **Upper Limit (Concrete Temp)**
- **Air Temp, F**
Heat Signature

- Cementitious system
- Strength development
  - Time of set
  - Sawing window
- Incompatibilities
- Uniformity
- Shift relates to initial temperature

*Saw cutting started-9hrs*
*Commonly 2± hrs around the peak*

**Peak Heat of Hydration**
Heat Signature
Heat Signature

Separated by Sample Days

Sample Day 1 & 4
Quality in the Concrete Paving Process

Heat Signature

TOLLWAY Data

PV Mixture (No Slag)
FRAP Mix: 1320 8/23/13
FRAP Mix: 1320 8/27/13
FRAP Mix: 1331 8/30/13
(Different Source of Fly Ash)

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Federal Highway Administration
Module 8-97
Hardened Concrete Properties

- **Strength**
  - Not a QC test
  - Not real time

- **Permeability**
  - Tremendous affect on the life of the pavement

- **CTE**
  - Very important in the pavement design
Compressive Strength

- Contractors Data
- Concrete or testing variability?
Compressive Strength

- Does air content match strength changes?

![Graph showing compressive strength changes over time with air content and 28 day strength requirements]
Quality in the Concrete Paving Process

Compressive Strength

![Graph showing compressive strength over time for different sample IDs.](image_url)

- 7 day
- 28 day
- 56 day

Sample ID:
- 1-1
- 2-1
- 3-1

Compressive Strength, PSI

- 2000
- 2500
- 3000
- 3500
- 4000
- 4500
- 5000
- 5500
- 6000
- 6500
- 7000
Quality in the Concrete Paving Process

Compressive Strength

Compressive Strength, PSI

Sample ID

Minimum Compressive Strength requirement at 28 Days

56 day
28 day
7 day
Compressive Strength

- Would less strength actually be better?
Compressive Strength

7 Day Compressive Strengths
28 Day Compressive Strengths
Permeability

- Surface resistivity Test
  - Easy and quick test
- Rapid Chloride Permeability Test
  - Takes more time and effort - old stand by

![Chart showing permeability test results with three categories: Low, Moderate, High for 7, 28, and 56 days.](chart.png)
Permeability

- **Surface resistivity Test**
  - Easy and quick test

- **Rapid Chloride Permeability Test**
  - Takes more time and effort - old stand by

![Graph showing the relationship between Surface Resistivity and RCPT](image)

\[ y = 12270x^{-0.836} \]
\[ R^2 = 0.7159 \]

- **Surface Resistivity, KOhm-cm**
  - High
  - Moderate
  - Low
- **RCPT, Columbs**
  - Low
  - Moderate
  - High
Permeability

- Surface Resistivity Test
  - Easy and quick test
- Rapid Chloride Penetrability Test
  - Takes more time and effort - old stand by

![Graph showing permeability test results](image)

- Low
- Moderate
- High

- No Slag in PV Mixture

**at 14 Days**
- FRAP Mixture
- PV Mixture

**at 28 Days**
- FRAP Mixture
- PV Mixture

**at 56 Days**
- FRAP Mixture
- PV Mixture
Quality in the Concrete Paving Process

Permeability

- Surface resistivity Test
  - Easy and quick test
- Rapid Chloride Permeability Test
  - Takes more time and effort - old stand by
- Cured in lime water

![Graph showing permeability test results with FHWA logos and categories: Very Low, Low, Moderate, High.](Image)
Permeability

- Surface resistivity Test
  - Easy and quick test
- Rapid Chloride Permeability Test
  - Takes more time and effort - old stand by
- Cured in moist room

![Graph showing permeability test results]

- **28 Day**
- **56 Day**

**MDOT**

- V. Low
- Low
- Moderate
- High
Heat Signature vs. Surface Resistivity

\[ y = 1351.9e^{-0.046x} \]

\[ R^2 = 0.9141 \]
Construction Monitoring/Acceptance

- HIPERPAV
  - Assess early age cracking potential

- Maturity
  - Measures real world conditions
  - For opening strength only
  - Not 28 day strength

- MIT-SCAN-2
  - Dowel bar location and alignment

- MIT-SCAN-T2
  - Pavement thickness
HIPERPAV

- Software tool for assessing cracking risk

Placement on 7/12/13 @ 11:00 p.m.
Field Maturity
Maturity

- Maturity curve
  - Temperature and time factor can be used to determine in-place pavement strength

Opening strength = 3000 psi
Pavement age = 7 days

Maturity number = 1600 °C-Hrs
Maturity

- Maturity readings
  - Sensors in the maturity and thereby strength for opening pavement determine in-place

![Diagram showing maturity readings](image)

- Maturity of Pavement
- Maturity of Standard Cured Cylinder

**Time Saving**

- 3000 psi
- 7 days
MIT-SCAN-2

Dowels Present along this line

No Dowels here
Identification of Problems

- Dowel bar inserter

- MIT SCAN 2
  - 25 joints scanned (both lanes)
  - 6 of 25 joints have no dowels
  - 3 of the 6 joints had dowels approximately 2 ½’ away from the joint
MIT-SCAN-2

- 27 Joints Tested
- No alignment issues
Quality in the Concrete Paving Process

MIT-SCAN-2

Cut

948+35  948+50  948+65  948+80  948+95
MIT-SCAN-T2
MIT-SCAN-T2

- **Thickness**
  - Design thickness = 9.0”
  - Average thickness (T2) = 9.7”
Quality in the Concrete Paving Process

MIT-SCAN-T2

\[ y = 0.987x + 0.0608 \]
\[ R^2 = 0.9802 \]

Scan T2 measurements, inches vs. Core Thickness, inches
Thank you for your attention.

Any final comments or questions?