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?
CPU 6 Learning Objectives

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

• Name four key inspection items of dowel bar placement
• Identify three inspection items for aggregate stockpiles
• Describe four advantages of stringless paving
• Explain the purpose of the two types of texture provided by the burlap drag and the tining.
• Name two aspects of sawing that are critical to preventing random cracks.
Pre-Paving and Mix Production
Pre-Paving Activities

Pre-Paving (Chapter 4)
- Subgrade/Subbase Construction
- Staking, Stringline and Stringless Construction
- Fine Grading
- Dowel Basket Placement
- Steel Placement (CRCP)
- Paver Preparation
Pre-Paving Activities

Pre-Paving (Chapter 4)

- **Subgrade/Subbase Construction**
- Staking, Stringline and Stringless Construction
- Fine Grading
- Dowel Basket Placement
- Steel Placement (CRCP)
- Paver Preparation
Foundation System

- Stiffness
- Stability
- Uniformity
Pre-Paving Activities

Pre-Paving (Chapter 4)
- Subgrade/Subbase Construction
- **Staking, Stringline and Stringless Construction**
- Fine Grading
- Dowel Basket Placement
- Steel Placement (CRCP)
- Paver Preparation
Staking and Stringline

- Paving hubs and construction stakes
  - Set to the proper offset and projected grade
- Stringline
  - Securely place pins
  - Adjust tension with winches and tie-offs
  - Eyeball for smoothness
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Stringless
Stringless Construction

- Advantages
  - Smoother pavement
  - Safer construction site
  - Eliminates staking operation
  - Facilitates one-lane construction
Pre-Paving Activities

Pre-Paving (Chapter 4)
- Subgrade/Subbase Construction
- Staking, Stringline and Stringless Construction
- **Fine Grading**
- Dowel Basket Placement
- Steel Placement (CRCP)
- Paver Preparation
Fine Grading

- Controls pavement thickness and smoothness
  - Check tolerances
  - Blend trimmed material with granular subbase to avoid segregation
  - Fill low areas, blend, recompact and fine grade
Pre-Paving Activities

Pre-Paving (Chapter 4)

- Subgrade/Subbase Construction
- Staking, Stringline and Stringless Construction
- Fine Grading
- **Dowel Basket Placement**
- Steel Placement (CRCP)
- Paver Preparation
Dowel Basket Placement

- Improper load transfer
- Faulting
Dowel Basket Placement

- Securing the baskets
Group Activity

- Which way is the paver moving?
Basket Layout

- Transverse spacing as specified (joint layout)
- Aligned correctly
Basket Placement

- Stakes or clips are adequate for anchoring the basket
- Adequate number of stakes/clips per basket
- Bond breaker
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Poor Dowel Alignment
Basket Inspection

- Specified coating and condition of coating
- Specified dowel diameter
- Correct basket height
- Dowel spacing
- Clean
Basket Location Marking

- Durable marking
- Pins
- Both sides of the pavement!
Pre-Paving Activities

Pre-Paving (Chapter 4)
- Subgrade/Subbase Construction
- Staking, Stringline and Stringless Construction
- Fine Grading
- Dowel Basket Placement
- **Steel Placement (CRCP)**
- Paver Preparation
Steel Placement (CRCP)

- Affects crack spacing
  - Adequate chairs for support
  - Periodically anchored into subbase to resist movement from the paver
  - Correct bar size and spacing
  - Staggered laps
Pre-Paving Activities

Pre-Paving (Chapter 4)
- Subgrade/Subbase Construction
- Staking, Stringline and Stringless Construction
- Fine Grading
- Dowel Basket Placement
- Steel Placement (CRCP)
- Paver Preparation
Paver Preparation

- Extrusion process
Slipform Paver Functions

- Consolidation
- Shaping
- Surface finish
- Pavement smoothness
Paver Preparation

- Vibrator spacing and operation
- Tie bar inserter location
- Fix hydraulic leaks

Hydraulic fluid is not a concrete admixture!
Paver Preparation

- Shaping
  - Slab dimensions
    - Side form dimensions
  - Pan settings
    - Cross slope
    - Crown breaks
    - Angle of attack
Paver Preparation

- Tie bar inserter location
Pre-Paving Activities

Plant Site and Mixture Production (Chapter 5)

- Aggregate Stockpile Management
- Plant Set-Up and Calibration
- Mixture Production
- Transporting Concrete
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Pre-Paving Activities

Plant Site and Mixture Production (Chapter 5)

- **Aggregate Stockpile Management**
- Plant Set-Up and Calibration
- Mixture Production
- Transporting Concrete
Aggregate Stockpile Management

- Minimize segregation
  - Build long and wide—NOT high!
  - Build stockpiles in tiers to avoid segregation

Picture courtesy of Martin Marietta Materials
Group Activity

What’s wrong with this picture?

Sampling
Aggregate Stockpile Management

- Uniform Moisture
  - Stable and well drained foundation underneath stockpiles
  - Place a separation layer on top of soil
  - Draw from areas of known moisture content
Aggregate Stockpile Management

- Contamination
  - Mud balls
Pre-Paving Activities

Plant Site and Mixture Production (Chapter 5)
- Aggregate Stockpile Management
- **Plant Set-Up and Calibration**
- Mixture Production
- Transporting Concrete
Plant Set-up and Calibration

- Calibrate scales and water meters
  - Each time the plant is set-up
  - At regular intervals

- Verify that the batch control computer
  - The correct mix design(s)
  - Appropriate aggregate moisture contents

- TEST BATCH!
Pre-Paving Activities

Plant Site and Mixture Production (Chapter 5)

- Aggregate Stockpile Management
- Plant Set-Up and Calibration
- **Mixture Production**
- Transporting Concrete
Verify Mixture Quality in the Field

- Mixture verification stage
  - Compares field concrete to the mixture design
- Is this the same concrete?
- Trial Batch

SAME?
Mixture Production

- Segregation resistance
- Air void system
- Uniformity
- Workability
- Strength
- Durability
- Shrinkage
Recommended Practices

- Use aggregates from areas of known moisture content
Recommended Practices

- Adjust moisture compensation as needed
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Recommended Practices

- Adequate mixing time
  - Uniformity
  - Air entrainment
  - Strength
  - Workability
Quality Control

- Monitor mixture quality during production and react to changes
  - Aggregate moisture and gradation
  - Concrete temperature
  - Slump
  - Unit weight
  - Air content
  - Microwave water content
  - Heat Signature
Pre-Paving Activities

**Plant Site and Mixture Production (Chapter 5)**
- Aggregate Stockpile Management
- Plant Set-Up and Calibration
- Mixture Production
- Transporting Concrete
Transporting Concrete

- Traffic considerations
- Anticipate the unexpected
Transporting Concrete

- Maintain haul route
Transporting Concrete

- Wash out trucks as necessary
Paving
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Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Spreading Concrete

- Place concrete in front of the paver
- Distribute concrete evenly
- Avoid segregation => effects
  - Permeability
  - Strength
  - Shrinkage
Spreading Concrete

- Continuous supply of concrete to the paver
- Consistent head => smoothness
- Communication
  - Spreader operator
  - Paver operator
QC Checklist Items

- Spreader width – narrower than paver
- Steering alignment with respect to paver
- Concrete depth behind the spreader—account for width and consolidation
QC Measurements

- Real Time / On-the-grade-tests
- All measure change
  - Unit weight
  - Air content / system
  - Concrete temperature
  - Slump
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Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Slipform Paver Functions

- Consolidation
- Shaping
- Surface finish
- Pavement smoothness
Consolidation

- Match vibrator frequency to workability and paver speed
- Electronic vibrator monitor
Over-Vibration

- Vibrator Trails
- Segregation
Shaping

- Extrusion pan – trueness and cross-slope/crown
- Adjust overbuild to form neat edges
- Curb dimensions
Shaping

- Paver attitude and extrusion pressure
  - Bug holes
  - Tears
Smoothness

- Don’t stop the paver
Smoothness

- Pad line profile influences slab profile
  - Therefore pad line design and construction impacts smoothness
QC Measurements

- Vibrator monitor
- Smoothness
- Thickness
Key Inspection Items

- One contractor example
  - Tape QC Inspection list on the paver
  - Offset alignment – every 50’
  - Stringline – constant
  - Edge slump – every 50’
  - Slab width – every 50’
Key Inspection Items

- Visually inspect the pavement edge and surface for proper consolidation.
- Some voids are preferable to having too much water on pavement surface.
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Appropriate Actions

- Adjust vibrator frequency
- Adjust speed
- Refine mixture proportions
- Stop paving if the edge keeps falling
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- **Insertion of Dowels and/or Tie Bars**
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Dowel Bar Inserters

- Insert dowels at planned locations
- Insure bond breaker is applied
- Mark the location of the dowels
- Check consolidation around the bars
Recommended Practices

- Mark dowel insertion locations for verification and sawing (BOTH SIDES!)
Check Dowel Location

- Real-time
- Non Destructive Testing (NDT)
- Core verification after first day
Real Time

- Verify dowel bar location behind the paver
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NDT Inspection Options

- Periodically verify steel location behind the paver
  - Cover meter (pachometer)
  - GPR after hardened
  - MIT-SCAN-2

U.S. Department of Transportation
Federal Highway Administration

CPU 6-77
MIT-SCAN-2

- One limitation
  - Cut the tie wires
Typical Practices

- Insert tie bars at planned locations
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Recommended Practices

- Fill surface voids
- Avoid over-finishing
Recommended Practices

- Identify bumps and dips
  - Overlap straightedge by 1/2
- Correct bumps and dips
Effect of Hand Finishing

Roughness Profile (in/mi)

Distance (ft)
Recommended Practices

- Burlap drag is clean
  - May need to clean or replace during the day
- Check hand tools for trueness
Typical Practices

- Wetting of the burlap
  - Uniform
  - Light application
Not Recommended Practices

- “Blessing” the slab
- Adding water to the surface
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Water/Cementitious Ratio

- How close are the duckies in your hot tub?
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- **Texturing**
- Curing
- Sawing
- Weather Adjustments
Texturing

- Micro texture
  - Drag texture with adequate contact area
  - Dry pavement friction
Texturing

- Macro Texture
  - Wet weather skid resistance
  - Reduce hydroplaning
Recommended Practices

- Steering and elevation controlled automatically
- Consistent operating speed
- Goal is:
  - Uniform/true grooves
Recommended Practices

- Adjust tine angle and length
  - Texture depth
  - Tine spacing
Minimize Positive Texture

- Results in more noise
  - Clean drags
  - Clean tines
  - Straight tines
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100 dBA

106 dBA
Appropriate Actions

- Do not delay texturing at the expense of curing
- Don’t let the tine rake stop in the down position
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- **Curing**
- Sawing
- Weather Adjustments
Key Inspection Items

- Cure as soon as practical
- Even and complete coverage
- Consistent operating speed
Key Inspection Items

- Edge covered also
- Even and complete coverage
Key Inspection Items

- Curing compound meets specification
- Emulsion
  - Agitate
  - Prevent freezing
Recommended Practice

- Apply cure before surface drying occurs
Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- **Sawing**
- Weather Adjustments
Recommended Practices

- Adequate number of saws on the project
Recommended Practices

- Joints marked accurately
Recommended Practices

Figure 8-23. Close-up of different degrees of raveling caused by joint sawing (ACPA)

- a) No raveling—sawed later in the window
- b) Moderate raveling—sawed early in the window
- c) Unacceptable raveling—sawed too early

Sawing window

Too early (raveling)  —  Too late (cracking)

Minimum strength to avert excessive saw cut raveling

Restraint stress equals concrete strength

Concrete strength

Time
Key Inspection Items

- Specified sawing depth and width
- Record and log sawing depth
- Ample saw blades on-hand
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Pre-Paving Activities

Placement, Finishing, Texturing, Curing and Sawing (Chapter 6)

- Spreading Concrete
- Slipforming
- Insertion of Dowels and/or Tie Bars
- Hand Finishing
- Texturing
- Curing
- Sawing
- Weather Adjustments
Prepare for Weather Changes

- Cold front sudden drop in temperature
  - Be prepared to cover
    - Plastic
    - Burlap
    - Blankets
  - Avoid thermal shock

- Use HIPERPAV to predict impact
Recommended Practices

- Use HIPERPAV to assess risk of cracking
- Refer to page 93 of the “Testing Guide”
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HIPERPAV
- Software tool for assessing cracking risk

Placement on the night of 5/21/12

@ 5:00 A.M.

Tensile Stress and Strength (psi)

Time of Day

6 AM 12 PM 6 PM 12 AM 6 AM 12 PM 6 PM 12 AM 6 AM 12 PM 6 PM 12 AM

0 50 100 150 200 250

U.S. Department of Transportation
Federal Highway Administration
HIPERPAV

- Software tool for assessing cracking risk

Placement on the night of 5/22/12 @ 4:00 A.M.
Wet Weather Considerations (Rain)

- Be prepared to cover
- Schedule hand pours, shoulders, etc.
- Do not finish-in rain water
- Grind/groove texture to remove damaged surface
Hot Weather Considerations

- Reduce mix temperature
- Sprinkle subbase
- Night placement
- Morning placements are most at risk
Cold Weather Considerations

- Increase mix temperature
- Reduce SCM content in the concrete mixture
- Do not place on frozen subgrade/subbase
- Cover slab to protect from freezing for 48 hours
- Replace cover after sawing to avoid thermal shock
- Monitor concrete temperature with recording devices
Concrete Properties and Testing
Air Void System

New Testing Devices

- Super Air Meter (SAM)
  - Modification of existing air test
  - Measures air system quality
    - Has its own scale to measure results
  - Test
    - Test three times at different pressures
    - Repeat
  - Small bubbles implode
  - Field friendly
Microwave Water Content

- Developed in SHRP
- Sample from the truck

Indicator for:
- Strength
- Permeability
- Uniformity
- Shrinkage
Permeability
(Surrogate Tests for Durability)

Rapid Chloride Penetrability Test (Indirectly)

- Became standard in 1977
- Most common test
- Indicator of vulnerability to water and chloride ingress
- Generally 24 hours to condition and 6 hours for testing

ASTM C1202
Permeability
(Surrogate Tests for Durability)

Wenner Probe/Surface Resistivity Test (Indirectly)

- Provisional AASHTO Standard
- TP 95-11
- State specification
- Louisiana: DOTD TR 233
- 28-day age is being used
- Instant results on hardened concrete
- Easily measures the right property
Heat Signature (Calorimetry)

- Measures the heat of hydration
  - Similar to maturity
    - Measures temperature of in-place, field concrete
  - Measure temperature under controlled conditions
- About a day and half
- Equipment is relatively inexpensive
- Procedure is simple:
  1. Cast a standard cylinder
  2. Place it in the calorimeter
  3. Push the ON button
Thank you for your attention.