FHWA
Mobile Concrete Technology Center

How do we build better concrete pavements

Jim Grove P.E.
ATI Inc. / FHWA

2019 South Carolina Concrete Conference
November 6, 2019
The Goal

Eddyville Cemetery Road
Eddyville, Iowa
Built 1909

110 Years Old Pavement
Concrete Mixture Goals

- Optimized combined gradation
- Minimize cementitious content
- Utilize Supplementary Cementitious Materials
- Minimize water/cementitious ratio (w/cm)
- Check for incompatibility mix design process
1. Are we testing the right quality characteristics?

- What do we test for acceptance?
  - Slump  "A slump test only measures slump"
  - Air content  Total air doesn’t insure durability
  - Strength  Strength is 28 days too late!

- Are we testing the right quality characteristics?
  - What really counts?
  - How do pavements fail?

- Can we do better?  YES!
What does the slump test really tell us?

- Water content?
  - It used to be an indicator of water content
  - Now water reducers will change the slump with no change in water

- Workability
  - Slump does not account for energy being added through vibration

- Change
  - Slump can tell us something has changed

AASHTO T 119
2. Are we testing in real time?

- **QC testing**
  - Need to make changes during construction
  - Prevent problems to insure quality

- **Agency Acceptance**
  - Risk costs money!
  - Waiting 28 days for strength test results
A New FHWA Initiative

In the past... **STRENGTH**

- We could measure it
- Best we had
- Thought to relate to long term performance
- If you mess it up, it always gets worse, not better
- **ONE-MAN BAND!!**
How do we know we are building long lasting pavements?

Past

Strength

Performance Engineered Mixtures (PEM) Changes Our Focus

Today

Durability 6 Properties
PEM Parameters

- Strength
- Cracking tendency
- Freeze-Thaw durability
- Permeability
- Aggregate stability
- Workability*
High Strength Issues

- Excessive strength issues from typical paving mixtures (13 states)

- FHWA one pager
Compressive Strength

Cylinders cast at the plant

Design Requirement at 28 Days

Compressive Strength, PSI

7 Day  28 Day  56 Day

1-1

2-1
The TARANTULA curve!!!!

Increases cohesion and reduces edge slumping

Decreases workability and promotes segregation and edge slumping

Decreases workability

Creates surface finishability problems
Optimized Gradation

- How do we achieve it?
- FHWA Spreadsheet

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<th>Fine 1 Agg</th>
<th>Fine 2 Agg</th>
<th>Inter Agg</th>
<th>Coarse Agg</th>
<th>Combined % Passing</th>
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Weights:

| %'s | 45% | 40% | 15% | 100% |

Image credit: Wisconsin Department of Transportation, Federal Highway Administration.
Optimized Gradation

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Wisconsin

Tarantula Curve

Shilstone Curve

8-18 Chart
Tarantula Curve

- Excessive amount creates workability issues.
- Creates surface finishability problems typically associated with manufactured sands.
- Excessive amount that decreases workability and promotes segregation and edge slumping.

Percent Retained vs. Sieve Size

- Excessive amount creates workability issues.
- Creates surface finishability problems typically associated with manufactured sands.
- Excessive amount that decreases workability and promotes segregation and edge slumping.
Super Air Meter (SAM)

- Measures plastic concrete
- Measures air system quality
- Modification of existing air test
  - Field friendly
    - 8-12 Minutes
    - Measures total air content also
    - Frequency of testing?
- Small bubbles dissolve
- Procedure
  - Test 3 times at increased pressures
  - Repeat

AASHTO TP 118
Thickness Testing

MIT-SCAN-T3
- Eliminates coring
- Saves time, money, manpower
- Many states are adopting
- **AASHTO T 359**

**Step 1**
Place the target

**Step 2**
Pave over it

**Step 3**
Find the target
MIT SCAN T3 Advantages

- Easy to use
- High accuracy
- Non-destructive
- Almost real time
- Rapid measurement
- Data storage (text files)
- Independent of the base material
- Calibration with cores not required
- Affords a huge increase in the number of measurements

Measure the thickness using magnetic pulse induction
MCTC Test Data

\[ y = 1.0289x - 0.3376 \]

\[ R^2 = 0.9967 \]
MIT-SCAN-T2

- **Thickness**
  - Design thickness = 13"
  - Average thickness = 14.3"

![Graph showing pavement thickness measurements with design and average thickness values.]
Check Dowel Location

- NDT Inspection Options (after concrete has hardened)
  - Cover meter (pachometer)
  - GPR (Ground penetrating radar)
  - Dowel SCAN

[Images of a pachometer, GPR equipment, and a worker using a GPR device]

Ground Penetrating Radar
Dowel SCAN Advantages

- Works on fresh or hardened concrete
- Real-time, automated data analysis
- Very accurate and reliable
- Efficient (1-2 min per joint)

- 200 or more joints can be tested in an 8-hr workday
- Up to 3 lanes can be tested in a single pass
Dowel SCAN

Problem Joints

Typical Joint

Basket spread Misalignment Bar missing

MCT data
Mobile Concrete Technology Center Activities

- Field visits to active construction projects
- Quality in the Concrete Paving Process Workshop
- Assist with (PEM) implementation
- Equipment Loan Program
- One-on-one Training
- Conferences, papers, and other activities
Program Goals

- Implement new and proven concrete technologies
- Evaluate new tests and equipment
- Demonstrate the benefits
  - of statistical materials acceptance
  - in agency acceptance programs
  - through industry quality control
- Assist states with concrete issues
  - Specification review and development
  - Technical assistance
  - Forensics

https://www.fhwa.dot.gov/pavement/concrete/trailer/
Equipment Loan Program

- States or industry can borrow MCT equipment
- MCT staff will provide training, if desired
- Substantial new equipment purchase
- PEM focus
Field visits 2019
New effort to use MCT data
Narrowly focused
Meant to stir interest and point reader to resources
- 1st: Cement Content
- 2nd: Optimized Mix Design
- 3rd: Cores vs. Cylinders
- 4th: NDT Pavement Thickness
- 5th: Tining/Surface Texture
- 6th: Surface Resistivity Test
- 7th: Maturity
- 8th: Curing
- 9th: SCM’s
- 10th: Calorimetry

www.fhwa.dot.gov/pavement/concrete/trailer/resources
The End of the Road!

Thank you for your attention.

Jim Grove  P. E.
ATI Inc. / FHWA
Office of Preconstruction, Construction, and Pavements
2711 South Loop Drive, Suite 4502
Ames, Iowa 50010
Phone: 515-294-5988
Mobile: 515-450-3399
jim.grove@dot.gov