FHWA Non-Destructive Evaluation for Pavements: A Webinar Series

Monica Jurado
FHWA Resource Center

July 27, 2020
Welcome to NDE for Pavements Webinar

- Every Month 1 HR Webinar
  - 1 for Pavements
  - 1 for Structures/Tunnels

- NDE Technologies used for Pavement
  - MCTC
  - MIT T2/T3
Michael F. Praul, PE

Mike Praul is the Senior Concrete Engineer in the Federal Highway Administration’s Office of Preconstruction, Construction, and Pavements.

• Mr. Praul leads a variety of FHWA initiatives in the areas of concrete materials, concrete construction, and quality assurance, including FHWA’s efforts to implement performance specifications for concrete.

• Mr. Praul manages the FHWA Mobile Concrete Technology Center Program which works to implement new concrete technologies throughout the country.

• Mr. Praul’s work in concrete and quality assurance has been formally recognized with a USDOT Secretary of Transportation Meritorious Service Award and with an FHWA Administrator’s Superior Achievement Award.

• In 2013, Mike received the National Leadership Excellence Award for Pavements and Materials.

• Mr. Praul holds a Bachelor of Science Degree in Civil Engineering from Clarkson University, a Master of Engineering Degree in Civil Engineering from Rensselaer Polytechnic Institute (RPI), and is a licensed Professional Engineer in the State of Maine.

• Mr. Praul has two grown daughters and lives in Augusta, Maine with his wife Jody and two dachshunds.
Measuring Pavement Thickness Nondestructively Using Pulse Induction Technology

Michael F. Praul, PE
Senior Concrete Engineer
FHWA Office of Infrastructure

FHWA Non-Destructive Evaluation for Pavements Webinar
July 27, 2020
MCTC Program Goals

- Implement new and proven concrete technologies (e.g., PEM/AASHTO PP 84)
- Evaluate new tests and equipment
- Demonstrate the benefits of statistical materials acceptance in both agency acceptance programs and industry quality control applications
- Assist States with concrete issues
  - Specification review and development
  - Technical assistance
  - Forensics/Troubleshooting

Source: Pixabay
MCTC Activities

- Field visits to active construction projects
- Quality in the Concrete Paving Process Workshop
- Equipment Loan Program
- Publications (One Pagers, papers, technical articles)
- Conferences
MCTC Field Visits

- On site for two weeks
- Fresh concrete testing (Week 1)
- Hardened concrete testing (Week 2)
- Open House
- Closeout meeting with preliminary data
- Draft report to FHWA Division and State DOT
- Final report (approximately 4 months)
- Workshop
MCTC Field Visits 2018-2019
Quality in the Concrete Paving Workshop

- Two-day workshop on concrete and the benefits a Quality Assurance (QA) Program
  - Increase concrete pavements life at reduced cost
  - Contactor benefits of improved Quality Control (QC)
  - New technologies and tools for testing and inspection

- Agency and Contractor Participation
  - Class size 30 to encourage discussion
  - DOT (QA/QC, Materials, Construction Staff, etc.)
  - Contractor staff (Superintendents, QC Managers, etc.)
  - FHWA Division Office staff
Equipment Loan Program

- States **or industry** can borrow MCTC equipment
- MCTC staff will provide training, if desired
- PEM focus
- 2018 new equipment purchase
Training

- One on one training to DOT engineers and technicians
- Side by side comparison of new technologies
Equipment Loan Program Success Story

MIT Scan T2

- Introduced to Iowa DOT during MCT visit in 2008
- Loaned to Iowa in 2008
- Two pilot projects in 2009
- Trial specification in 2010 (four projects)
- Full specification in 2011
- Iowa DOT purchased a unit for all six districts

- 2014-2016: Iowa DOT and MCT worked jointly to develop AASHTO Provisional Test Method
Conferences

2018
- MD Concrete Conference
- NY Construction Materials Association Technical Conference
- Texas Concrete Conference
- ASCE Indiana State Section Annual Meeting
- Roadway Management Conference (PA)

2019
- PA Concrete Conference
- Federal Lands Construction Discipline Seminar
- National Road Research Alliance Conference (MN)
- UDOT Concrete Conference
Based on trends identified by the MCTC
Narrowly focused
Meant to stir interest and point reader to resources

- Cement Content
- Optimized Mix Design
- Cores vs. Cylinders
- NDT Thickness Measurement
- Surface Resistivity
- Texture of Concrete Pavements
- Maturity
- Curing
- Supplementary Cementitious Materials
- Calorimetry
- Workability Tests
- Air Entrainment
- Stringless Paving
Mobile Concrete Trailer

Transferring Advanced Concrete Technology To Our Partners

https://www.fhwa.dot.gov/pavement/concrete/trailer/
Questions ???

• Contact info
  Michael.Praul@dot.gov
  207-512-4917
Jagan Gudimettla currently works as the Project Manager for the FHWA Mobile Concrete Technology Center.

- Mr. Gudimettla has been working as a consultant for the FHWA since 2003.
- Work has taken him to all 50 states where he demonstrated new technologies and best practices to transportation professionals from agencies, industry, and academia.
- Mr. Gudimettla’s areas of interest include quality assurance, advanced material testing, non-destructive testing and pavement design.
- Mr. Gudimettla received his master’s degree in Pavements/Materials from Auburn University and is a Registered Professional Engineer in Virginia, Maryland and California.
Measuring Pavement Thickness Nondestructively using Pulse Induction Technology

Jagan Gudimettla, P.E.
MCTC

FHWA Non-Destructive Evaluation for Pavements Webinar
July 27, 2020

Unless otherwise noted, FHWA is the source for all images.
Acknowledgments

- Todd Hanson (Iowa DOT)
- Kevin Jones (Iowa DOT)
- Chad Hayes (Wisconsin DOT)
- Robert Golish (Minnesota DOT)
- Gregory Johnson (Minnesota DOT)
- Richard Howell (Minnesota DOT)
Outline

- Pavement Thickness
- Pulse Induction Method
- State DOTs Experiences
  - Concrete Pavement Thickness
  - Asphalt Pavement Thickness
  - Soil Lift Thickness
- Current State of Practice
- Summary
Traditional Tests

- Probing (Quality Control)
- Coring (Acceptance)

- Destructive
- Expensive
- Time Consuming
  - core
  - inspect
  - handle
  - measure
  - patch core holes
Pulse Induction Technology

- Quality Control and Agency Acceptance
- AASHTO Test Method (AASHTO T 359-18)
- ASTM Test Method (ASTM E3209)

Step 1: Place the target
Step 2: Pave over it
Step 3: Find the target and measure thickness
Pulse Induction Technology

Advantages

- Easy to use
- High accuracy
- Non-destructive
- Almost real time
- Rapid measurement
- Significant cost savings
- Data storage (text files)
- Independent of the base material
- Calibration with core not required
Pulse Induction Technology

Accuracy

FHWA Mobile Concrete Technology Center (MCT) Data

\[ y = 1.0289x - 0.3376 \]
\[ R^2 = 0.9967 \]
Pulse Induction Technology

Repeatability

<table>
<thead>
<tr>
<th>Precision</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1S D2s</td>
<td></td>
</tr>
<tr>
<td>Single Operator</td>
<td>0.3% 0.8%</td>
</tr>
<tr>
<td>Multiple Laboratory</td>
<td>0.5% 1.3%</td>
</tr>
</tbody>
</table>

Iowa DOT Data

T2-A vs. T2-B
388 Locations

Y = 0.9983X
R² = 0.9984
STD Error = 1.17
Pulse Induction Technology

- GPS enabled
- Hardware enhancements
- Software enhancements

Limitations

- Only for new construction
- Measurements 2-3 feet away from steel

MIT Scan T2

MIT Scan T3
Pulse Induction Technology

Metal Targets or Reflectors
Field Implementation

- FHWA Mobile Concrete Trailer (MCT)
  - Since 2007
  - Field Visits
  - Equipment Loan
Field Implementation

- FHWA Mobile Concrete Trailer (MCT)
  - Since 2007
  - Field Visits
  - Equipment Loan
Timeline

- Technology introduced (Spring 2008)
- Equipment Loan (Fall 2008)
- Evaluated the technology on two projects (2009)
- Trial Specification – four projects (2010)
- Full Specification (2011)
- Purchased several devices for each of their 6 districts

- Worked with MCT staff to develop an AASHTO Test Method (2014-2015)
If the MIT Scan T2 needs metal targets... Do we lose the element of random sampling (surprise)?
Iowa DOT

Procedure

- Place targets every 200 ft randomly 4 or 8 foot right or left of centerline (avoid steel)

- One nail hole in the middle of the target

Photo Courtesy: Iowa DOT
Procedure

- Random number (~50 to 65%) of targets are randomly selected

- The MIT Scan T2/T3 is used to find the location of the target

- Test by slow walking speed.
  - Test 3 times. Results need to be within 3 mm, if not, 2 additional readings are taken

Photo Courtesy: Iowa DOT
Old Spec

Core 1 random location every 2000 sq. yds.

New Spec

Four metal targets every ~2000 sq. yds.

Two MIT Scan measurements every ~2000 sq. yds.

Photo Courtesy: Iowa DOT
Iowa DOT

Issues with Granular Subbase

- 9-point measurement
- Concrete migrates into the aggregate base
- Core test results are slightly thicker

Core off target, core on target
Thickness index =
(Average Thickness – Std Dev.) – Design Thickness

Thickness Incentive
- Unit price adjusted up to 103% - or less
- Correction for type of base

<table>
<thead>
<tr>
<th>Type of Base, Subbase, Subgrade just below the concrete</th>
<th>Adjustment to Design Thickness for Incentive Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Subgrade or Soil Aggregate Subbase</td>
<td>Design Thickness</td>
</tr>
<tr>
<td>HMA Base, PCC Base, or Asphalt or Cement treated Base</td>
<td>Design Thickness</td>
</tr>
<tr>
<td>Modified Subbase or Special Backfill</td>
<td>Design Thickness minus 0.25 inches</td>
</tr>
<tr>
<td>Granular Subbase</td>
<td>Design Thickness minus 0.35 inches</td>
</tr>
</tbody>
</table>
Iowa DOT

- Currently has 12 MIT Scan T2 and 6 MIT Scan T3
- Agency tests verification and Materials checks Independent Assurance with different gage
Timeline

- Since 2013
  - Dowel baskets and tie steel
- Evaluated for thickness in 2015 and 2016: 9 pilot projects
- Select projects in 2017 and 2018
  - Contractor request for using the T2, no cost supplemental
- Starting in 2019 (Special Provision) all projects
  - Concrete overlay of an existing asphalt pavement
  - Concrete placed directly on the grade
- Not used on UBOL
  - Due to steel in the existing concrete
Frequency of Testing

Prior to 2014
- Coring frequency was 1 per 1000 lineal ft per lane

2014 to current (reduced coring and implemented more probing)
- 1 probe per 1000 lineal ft per lane
  - 1 verification core per 4 probes
- 1 random core per 4000 lineal ft per lane

2019 and beyond (Special Provision)
- 1 scan per 1000 lineal ft per lane
  - 1 verification core per 8 scans
- 1 random core per 8000 lineal ft per lane

Cores and scans will be used to determine final average thickness
Started using Thickness for Acceptance

2017

Ownership

- Department owns MIT Scan T2 devices.
- Department supplies contractors the plates and the plates are contractor installed.
Wisconsin DOT

Procedure

- 250 ft basic units (for each lane)
- Two plates in each unit installed by contractor
  - Longitudinal and transverse locations randomly determined
  - Must be a minimum of 3 feet from any steel
  - Anchor plates using 16D common nail
Procedure

- The department measures thickness at one random location in each unit.
- If the initial measurement falls within the 80 to 50 percent pay range, the department will measure at the second plate in that unit and average the results to determine pay adjustments.
Wisconsin DOT

### Thickness Penalty

<table>
<thead>
<tr>
<th>Pavement thinner than plan thickness by</th>
<th>Percent of the Contract Unit Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0.25 in but ≤ 0.5 inch</td>
<td>80</td>
</tr>
<tr>
<td>&gt; 0.5 in but ≤ 0.75 inch</td>
<td>60</td>
</tr>
<tr>
<td>&gt; 0.75 in but ≤ 1 inch</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 1 inch</td>
<td>unacceptable</td>
</tr>
</tbody>
</table>

The department adjusts pay based on the average of 2 measurements per unit.
What about Asphalt Pavements?

- Tonnage (asphalt) versus SqYards (concrete)
- Cores for density purposes (asphalt)

Minnesota DOT Experience

- West Central district uses a pay item of square yard inch (SYI) for asphalt
  - Personnel Issue
    - Weight tickets - Fewer agency folks in the field
- Additional cores are taken (above the normal density cores) to verify pavement thickness
Asphalt Pavements Minnesota DOT Experience

Procedure

- Targets placement
  - Immediately prior to paving
  - Discs placed on the base
    - Invisible after the first lift (randomness)
  - 4.7” plates, secured with one nail
- Number of plates based on the total tonnage
  - Vary based on pavement thickness
- Graduated deduction if paved too thin

Photos Courtesy: Minnesota DOT
Soil Lift Thickness – University of Delaware Experience

- Compacted soil test pad, US 301, Middletown, DE
- Determined backfill thickness at 82 locations
- Physical measurements using a caliper and steel ruler for thinner and thicker lifts respectfully.

Data and Photos
Courtesy: University of Delaware
State of Practice

Full-Fledged Implementation

- Iowa DOT
- Nevada DOT
- Alabama DOT
- Illinois Tollway
- Wisconsin DOT
- Minnesota DOT
- Pennsylvania DOT*
- West Virginia DOT
- North Carolina DOT*  
* Certain Districts
Planned Activities

Implementing in 2020
- Washington State
- North Dakota (two projects)
- Kansas (one district)
- Idaho (one project)

Considering implementing in 2021 or beyond
- Colorado
- Delaware
- South Carolina
Interesting Success Story

North Carolina

- Pavement Thickness
- Average Thickness
- Design Thickness

Used in lieu of coring for the rest of the project
Interesting Success Story

North Carolina

Safety Considerations

Dowel Bar Identification
Contractors Perspective

- Need not wait until the cores are cut for payment
- Cutting fewer or no cores
- In case of disputes, core is taken over the metal plate
  - The scanner has been shown to be accurate.
- Dowel bar detection for marking the joints
Summary

- Based on the State’s Data
  - Excellent correlation to core test results
  - Repeatable between operators and equipment
  - Can work for both concrete and asphalt pavements

- Proven technology for Quality Control and Agency Acceptance

- Major Benefits
  - Better statistical data (agency)
  - Almost real-time testing (contractor)
    - Reduced risk
  - Cost, time, personnel, safety (agency and contractor)
Resources


- Interlaboratory Study to Determine the Precision of the MIT Scan T2 for PCC Pavement Thickness. Report MLS-14-01, Iowa Department of Transportation, 2015.

Questions ???

Contact info:
Jagan.m.Gudimettla.ctr@dot.gov
202-366-1335
Please Join us for the Next Webinar:

- NDE for Structures:
  - August 31, 2020
  - 1:00 PM ET

- NDE for Pavements:
  - September 28, 2020
  - 1:00 PM ET
FHWA NDE for Pavements: A Webinar Series

Monica Jurado
Pavement and Materials Engineer
Monica.Jurado@dot.gov
720.456.2922