Performance Engineered Concrete Mixtures in Michigan

National Concrete Consortium

April 25, 2018

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In the "Relative" Beginning,

- Midwest Concrete Consortium (MCC)
 - Established 1997
 - State reports and meeting discussion topics:
 - Aggregate gradation and optimization
 - Aggregate quality
 - Alternative durability-based field tests
 - Alternative materials
 - Early 2000's
 - Circa "Maria"
 - Started rolling up our sleeves toward "Engineered" mixture concepts

Evolution of Optimized Concrete Mixtures in Michigan

- 1996 Started asking the question...Where's the Beef?
- 1997 First generation three aggregate optimized aggregate blend, required
 - 4A: 1 ¹/₂ inch nominal top size (between AASHTO No. 3 and No. 357)
 - 6AA: 1/2 to 3/4 inch nominal top size (similar to AASHTO No. 57)
 - 2NS: Natural sand
 - Enhanced freeze-thaw quality coarse aggregates
 - Optional SCMs
- 1998 First interstate reconstruction projects using 40/60 blend
- 1998 2003: A few projects with larger top size 2-inch nominal top size
 - Created two valleys...not good...too harsh
- 2004
 - Abandoned required standard gradations
 - Coarse, intermediate, and fine labels, with 5-15 and CF/WF criteria

Evolution of Optimized Concrete Paving Mixtures in Michigan

- 2010 First version of current QC/QA special provision
 - Defined independent QC and QA sampling and testing protocol
 - Reduced cementitious material content
 - Pavements 470-564 lbs/cyd
 - Mandatory 25-40 percent SCM
 - ASR requirements for fine aggregate
 - Pay factor for air content
 - Mandatory optimization using CF/WF criteria (with a few haystack rules)
 - Percent within limits quality index analysis for pavements
- 2017 Expanded mixture requirements to structures

The Roles of Contractor vs. Agency

- 2010
 - Separate roles QC/QA
 - Made the contractors part of the quality process
 - QC Plan
 - Warranties
 - Shifted some of the risk onto the contractors

Bringing the Contractor Expertise and Perspective to the Table

- Military Airfield Paving
 - Experience with performance engineered mixtures
 - Optimized gradation really works
 - Support for gradation control specifications
- Looking Beyond PEM
 - Performance engineering is more than just the concrete mixture
 - The pavement structure is also important
 - Drainable
 - Stable
 - Long-term subgrade protections

Southeast Michigan (Metro) Concrete Pavements

- 2005 MCA commissioned the CP Tech Center
 - Hardened air
 - Quality
 - Stability
 - ASR
 - Introduced SCMs to local network
 - Construction practices contractor participation in solutions
 - Mixing efficiency
 - AVA
 - Curing

Then along came the "Bombshell"

- Pavements constructed in the late 1990's and early 2000's were experiencing problems with joint deterioration
- Something was not right !!!
- Not an aggregate durability problem
- Paste decomposition





M-6 Grand Rapids "Poster Child"



Stretch of M-6 is 12 years old but needs 'total repair,' MDOT says

Not what we wanted to see !!

GRAND RAPIDS NEWS

Crumbing concrete on M-6 will be replaced with asphalt this summer

Posted on June 9, 2017 at 3:11 PM



Asphalt patching covers concrete joints on M-6 west of Wilson Avenue, along a stretch that the Michigan Department of Transportation is planning to re-do this year with asphalt. (Courtesy | MDOT)



Commissioned CP Tech Center to help "Share the Pain"

- Massive joint decomposition.
- Was it a result of:
 - Deicer?
 - Poor quality air-void system?
 - SCMs...contractor "option"
 - Poor subsurface drainage?
 - All of the above?
- Media barrage was brutal !!



Current Pooled-Fund Project Participation

- 2014 MDOT along with 18 other state DOTs: "Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures", TPF-5(297). Completion date: 2019
 - Lead state Oklahoma DOT
 - This pooled fund initiative is focused on the development of the SAM
- 2017 MDOT along with 14 other states and the FHWA: *"Performance Engineered Concrete Paving Mixtures"*, TPF-5(368). Completion date: 2021
 - Lead state Iowa DOT
 - The National Concrete Consortium (NCC) will be the anchor organization for dissemination of research and outreach for this project (32 dots, industry, academia)
 - This pooled effort will greatly aide toward developing Michigan-based specifications for incorporation of PEM protocol into the MDOT concrete quality assurance program

Roads Innovation Task Force (RITF)

- SAM and Resistivity will be demonstrated on two concrete demo paving projects:
 - 30-year design life (50-year service life): Bay Region, I-69 from I-75 to I-475. July 2017 project letting. May 2018 paving
 - 50-year design life (75-year service life): Grand Region, US-131 from 10 Mile Road to 14 mile Road. Spring 2018 project letting. Spring 2018 paving
 - QC and QA informational shadow testing via "Special Provision for Durability Based Field Testing"





State Transportation Innovation Council

- Federal Grant for Deployment of Innovative Technologies
 - Two grants were awarded to MDOT in 2016
 - STIC Application Implementation of SAM
 - Total: \$90,000 (\$72,000 Federal Funds, \$18,000 State Funds)
 - SAM Acquisition
 - Training, Spec Development, Outreach
 - Implementation

Training and Equipment Acquisition

- Pre-2017
 - Acquired two SAMs via pooled-fund study, TPF-5(297)
- Spring 2017 STIC activities
 - Purchased eight SAMs (total 10, to date)
- Summer 2017
 - Brought Dr. Ley in for a Joint MDOT/MCA training course
 - Day-long event (classroom and practical laboratory setting) 30 attendees
 - MDOT technicians 12
 - MDOT Supervisors 3
 - Wayne County Road Commission 1
 - Contractors -2
 - Concrete Suppliers 1
 - Consultants 6
 - MCA Staff 5
 - Six MDOT SAMs sent to Regions for outreach



Training and Equipment Acquisition

- Spring 2018 STIC activities + RITF
 - Purchased nine more SAMs (total 19, to date)
 - Brought Dr. Ley back for a Joint MDOT/MCA training/certificate course and "Train the Trainer"
 - Day-long event (classroom and practical laboratory setting) -23 attendees
 - MDOT/consultant QA technicians 13
 - MDOT central office technician (monitors) 2
 - Contractor QC technicians 8
 - SAMs will be sent back to Regions for 2018 outreach, as well as RITF shadow testing



AASHTO Committee on Materials and Pavements (COMP) (formerly Subcommittee on Materials)

NCC versus COMP

- Technical Sections
 - 3a, Hydraulic Cement and Lime
 - 3b, Fresh Concrete Properties
 - 3c, Hardened Concrete Properties
- Adopted the SAM as a Provisional Standard Test Method in 2016 (TP-118)
- Provisional Standard Practice for PEM (PP-84)

MDOT Moving Forward

- Complete STIC obligations
- Partner with MCA to incorporate SAM training module into current MCA Level 1 certified concrete technician course – 2018
- Continue active participation in pooled-fund projects:
 - "Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures", TPF-5(297),
 - "Performance Engineered Concrete Paving Mixtures", TPF-5(368)
 - Engage with Dr. Weiss toward implementation of resistivity meter
- MCA is also a contributing partner in PEM project, TPF-5(368)
- Pooled-fund engagement will help steer future MDOT implementation of PEM

MDOT Lessons Learnt

- Don't attempt development and implementation "in a bubble"
- Work within "reasonable" material production and handling constraints
 - What's good for paving may not work for ready-mix applications
 - Listen to the aggregate producers
- Incremental implementation of new tests...don't force the issue !
- Consistency between Contractor QC and Agency QA
- Pilot and shadow demonstration projects recommended
- Need sound data prior to implementing for acceptance
- Need continual data collection for PWL calibration

MDOT Current Optimization versus Tarantula Curve



Questions?