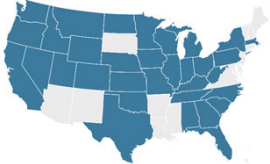


MDOT
Michigan Department of Transportation

About the Presenter

NCC
NATIONAL
CONCRETE
CONSORTIUM

- ▶ **Ethan Bahmer** is the Concrete Construction Engineer for the Michigan Department of Transportation.
- ▶ He's been with the Michigan Department of Transportation for over 5 years. During this time he's been involved with research, writing and reviewing specifications, design and construction.
- ▶ He also holds a Masters of Science degree in Civil Engineering from Michigan State University.

Performance Engineered Mix Testing

(PEM Testing)

MDOT
Michigan Department of Transportation

PEM Testing:

- ▶ **V-Kelly Ball (V-Kelly):**
 - ▶ Have used in the lab
 - ▶ Have not required its use on Projects
- ▶ **QC Test**




PEM Testing:

- ▶ **Box Test:**
 - ▶ Have used it in the lab
 - ▶ Have not required its use on Projects
 - ▶ Perhaps require its use for trial batches
- ▶ **QC Test**




PEM Testing:

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
MATURITY METHOD FOR DETERMINING CONCRETE
OPENING TO TRAFFIC TIME

C&T.TES 1 of 2 C&T:APPR:JFS:MJE:03-19-04

a. Description. The maturity method for determining the strength of Portland cement concrete involves monitoring the in-situ temperature development versus strength gain over time. Use this information to calculate the maturity, or time-temperature factor (TTF). Use the maturity information to estimate the in-situ strength of the concrete for opening to traffic purposes.


b. Equipment. Use a maturity testing system capable of automatically recording temperature readings and maturity calculations. The system must provide wireless two-way radio frequency communication with sensors that are embedded in the concrete. The sensors must record time, date, and temperature for each measurement interval. The measurement interval must be user definable. The system must store and be able to output sensor location, time of concrete placement, temperature, and TTF values for the duration specified by the Engineer. The maturity testing system must be approved by the Engineer prior to use on the project.

c. Procedure.

Establish Strength-Maturity Relationship (fingerprint). Fabricate a minimum of twelve - 6 x 6 x 20 inch flexural strength test beams from at least a 4 cubic yard concrete batch, according to ASTM C 31, to create the fingerprint. The fabricated test beams must be located away from construction traffic and protected from direct sunlight and wind. Record the slump, air content, and temperature of the fresh concrete. The concrete used for the fingerprint will be proportioned using materials, batch weights, and physical characteristics specified for the

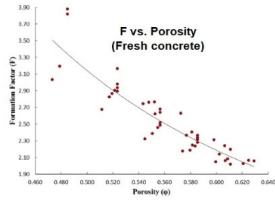
- ▶ Maturity Method:
 - ▶ **MDOT has specific requirements**
 - ▶ Special Provision
 - ▶ Contractor's option to use
 - ▶ Couple of projects a year





PEM Testing:

- ▶ Formation Factor:
 - ▶ MDOT has not used the formation factor
 - ▶ Mainly focused on resistivity testing




F vs. Porosity (Fresh concrete)

Source: Salehi et al. (2018)

FOR INFORMATION ONLY

PEM Testing:

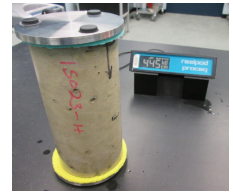
- ▶ Surface Resistivity:
 - ▶ Testing was performed on 2 long life (30 and 50 year) pavement projects
 - ▶ Was being conducted on all freeze-thaw samples
 - ▶ 40+ sets of coarse aggregate samples were tested
 - ▶ All testing and mix ingredients were provided to Jason Weiss
 - ▶ MDOT's experience:
 - ▶ Fairly high level of variability
 - ▶ Must hold Probes perpendicular to the surface
 - ▶ Ensure the Probes' reservoirs are full
 - ▶ Keep Probes away from voids and aggregate located on the surface
 - ▶ Currently MDOT is collecting data



FOR INFORMATION ONLY

PEM Testing:

- ▶ Bulk Resistivity:
 - ▶ Currently being conducted on all freeze-thaw samples
 - ▶ Used on multiple research projects
 - ▶ MDOT's experience:
 - ▶ Simpler test than surface resistivity
 - ▶ Consistent results
 - ▶ Ensure the sponges remain wet
 - ▶ Keep away from metal
 - ▶ Currently MDOT is collecting data



FOR INFORMATION ONLY

PEM Testing:

- ▶ Super Air Meter (SAM):
 - ▶ MDOT owns 19 SAMs
 - ▶ Introduced to Region personnel
 - ▶ Shadow SP:
 - ▶ 12CF601
 - ▶ Requires testing for information only:
 - ▶ Mainline Pavement
 - ▶ Structures
 - ▶ Barrier
 - ▶ One test per subplot
 - ▶ Typically 5 tests per day for mainline paving



PEM Testing:

- ▶ Super Air Meter (SAM):
 - ▶ Shadow SP: 12CF601
 - ▶ Placed in multiple projects:
 - ▶ Previous:
 - ▶ I-75 Monroe
 - ▶ I-131 Grand Rapids
 - ▶ I-69 Flint
 - ▶ Current: I-496 Lansing
 - ▶ Future projects
 - ▶ Information provided to Federal Highway and CP Tech Center



PEM Testing:

- ▶ Super Air Meter (SAM):
 - ▶ Michigan Concrete Association's SAM certification Class:
 - ▶ 2 training classes completed
 - ▶ 3 certification classes completed
 - ▶ 3 upcoming classes (postponed due to covid)



PEM Testing:

- ▶ Super Air Meter (SAM):
 - ▶ MDOT's Experience:
 - ▶ Introduce the SAM gauge
 - ▶ Inspectors experience ↑
 - ▶ Time to run the test ↓
 - ▶ Do not store wet gauges in cases
 - ▶ Do not leave the gauges in the air-conditioned cab prior to testing
 - ▶ Always have spare batteries
 - ▶ Have a backup gauge
 - ▶ Use the Shotgun
 - ▶ Follow the gauge's directions



PEM Testing:

- ▶ Super Air Meter (SAM):

- ▶ Future Use:

- ▶ QC?
 - ▶ Mix Design Verification?
 - ▶ Quality Assurance Daily Test?
 - ▶ Random number Testing?
 - ▶ PWL?



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Works Cited:

- ▶ H. Sallehi, P. Ghods, O.B. Isgor, Cement and Concrete Composites, 91: 174-188, 2018.