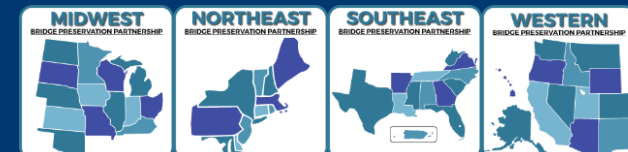


# INDOT - Bridge Preservation using Nanosilica-Enhanced Overlays



Adam Post, INDOT

Robert W Cavaliero, E5 Inc.



# Disclaimers

- Much of INDOT information taken from slides prepared by Mike Nelson, Concrete Engineer from INDOT Materials & Tests
  - [mnelson@indot.in.gov](mailto:mnelson@indot.in.gov)
- E5<sup>®</sup> / Specification Products
  - INDOT does not work for or market for them.
  - These are unique and proprietary products.
  - Can't just call them nanosilica-enhanced or modified colloidal silica as it's not only the products that makes it unique but also the batching process.

# INDOT's history of use of E5 in Decks



- Deck



- Overlay

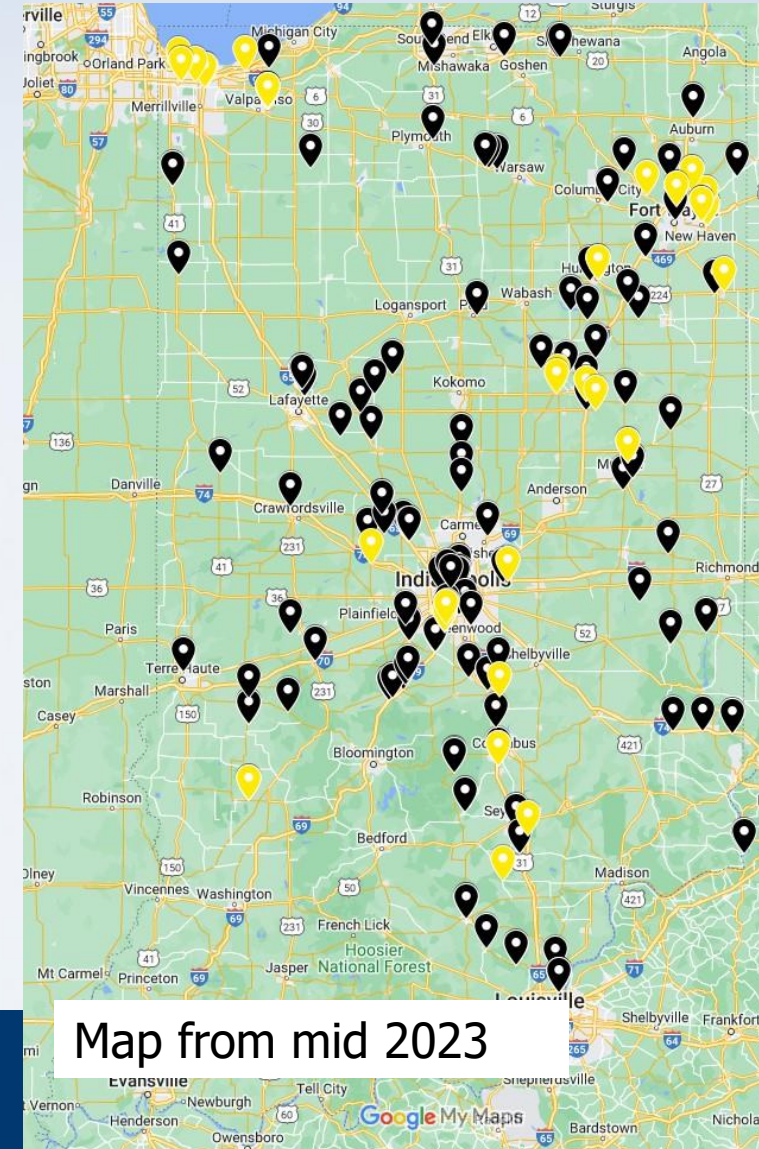
## Full-depth decks

- 291 pours (27 -2020, 46 -2021, 118 -2022, 75 -2023, 25-2024)
  - 2020/2021 – Curing compound only
  - 2022/2023 – Plastic sheeting only
  - 54 pours – E5-IC (internally cured) w/ 3% silica fume
  - 101 pours – E5-IC w/ 30% slag cement
  - 127 pours – E5-IC & E5-LFA (liquid fly ash) (started in 2022)

## Deck Overlays

- 3 pours in 2020 (unsuccessful)
  - Added E5 IC to existing SFMC mix (658# cement)
- 103 pours (17 -2021, 26 -2022, 37 -2023, 23-2024)
  - Traditional 7-day wet cure
  - E5-IC & E5-LFA & fiber (no bagged silica)

All decks and overlays were contractor's option per construction memos 21-05, 22-02, 22-04, 23-01, and 24-03



# INDOT's history of use of E5 in Decks

## Benefits

### Placement / plastic concrete (what to watch)

- Improved workability
- No water applied on the surface
- Longer window for finishing, but same set time
- Minimal bleed rate
- Eliminate evaporative retardants (90% water)
- Consistent mix / air entrainment
- Lower pump pressure
- More forgiving – better consistency
- No wet curing (curing compound vs plastic)
- No Supply chain issues
- Makes contractors better

Original goal:

Resolve issues behind the screed



# INDOT's history of use of E5 in Decks

## Benefits

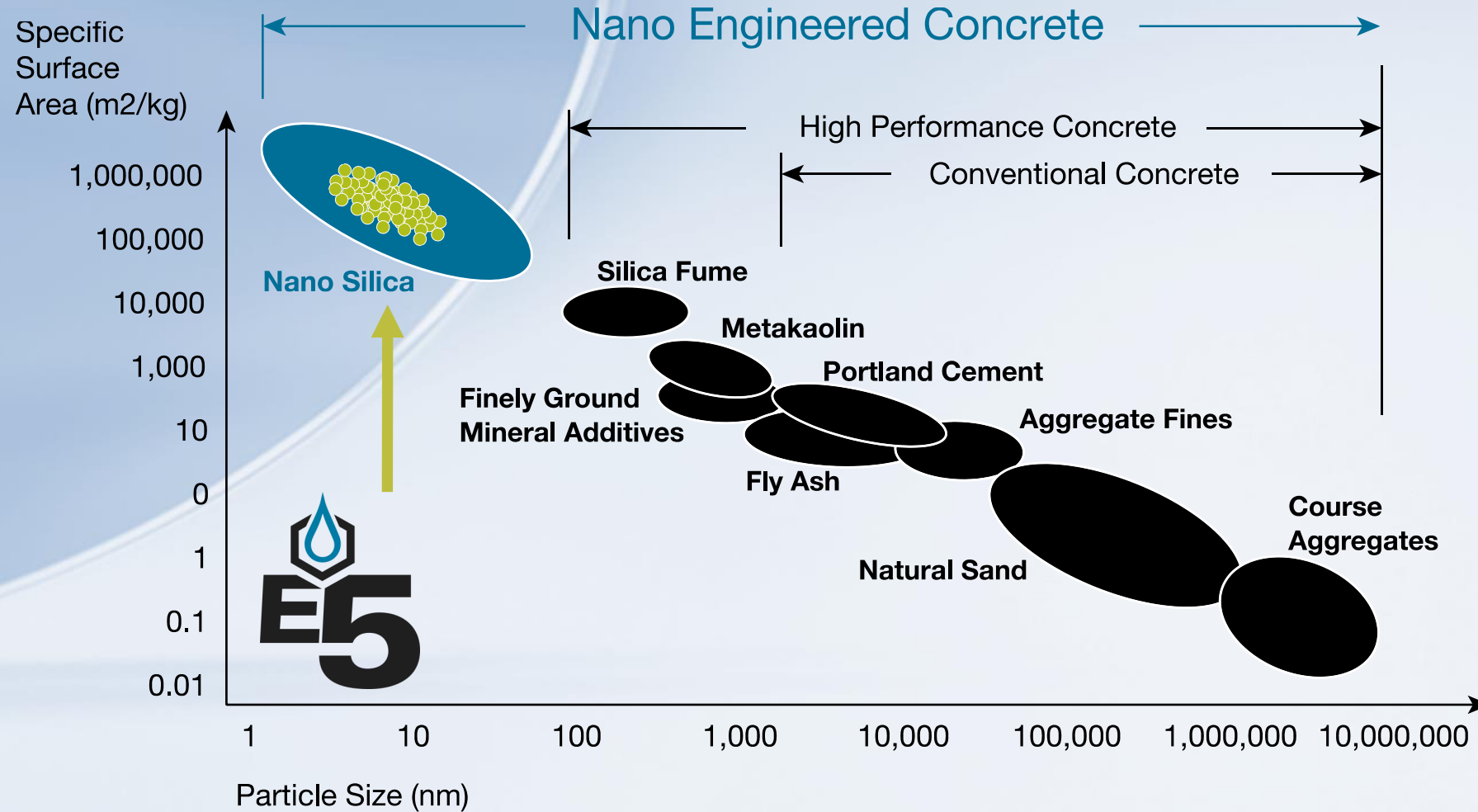
### Hardened concrete

- Minimal to zero material-related cracking
- Reduced permeability
- Cement/paste reduction
- Improved strength
- Reduced CH & Ca-Oxy (TRB 10-2022)
- Excellent bonding (overlays)
- Hardened air
  - Careful w/ external vibration @ higher slump

Disclaimer: **INDOT does not use these materials to mitigate ASR (alkali silica reaction)**

*(also known as concrete cancer – a chemical reaction that occurs in concrete over time when alkaline cement paste reacts with reactive silica in aggregates in the presence of moisture)*

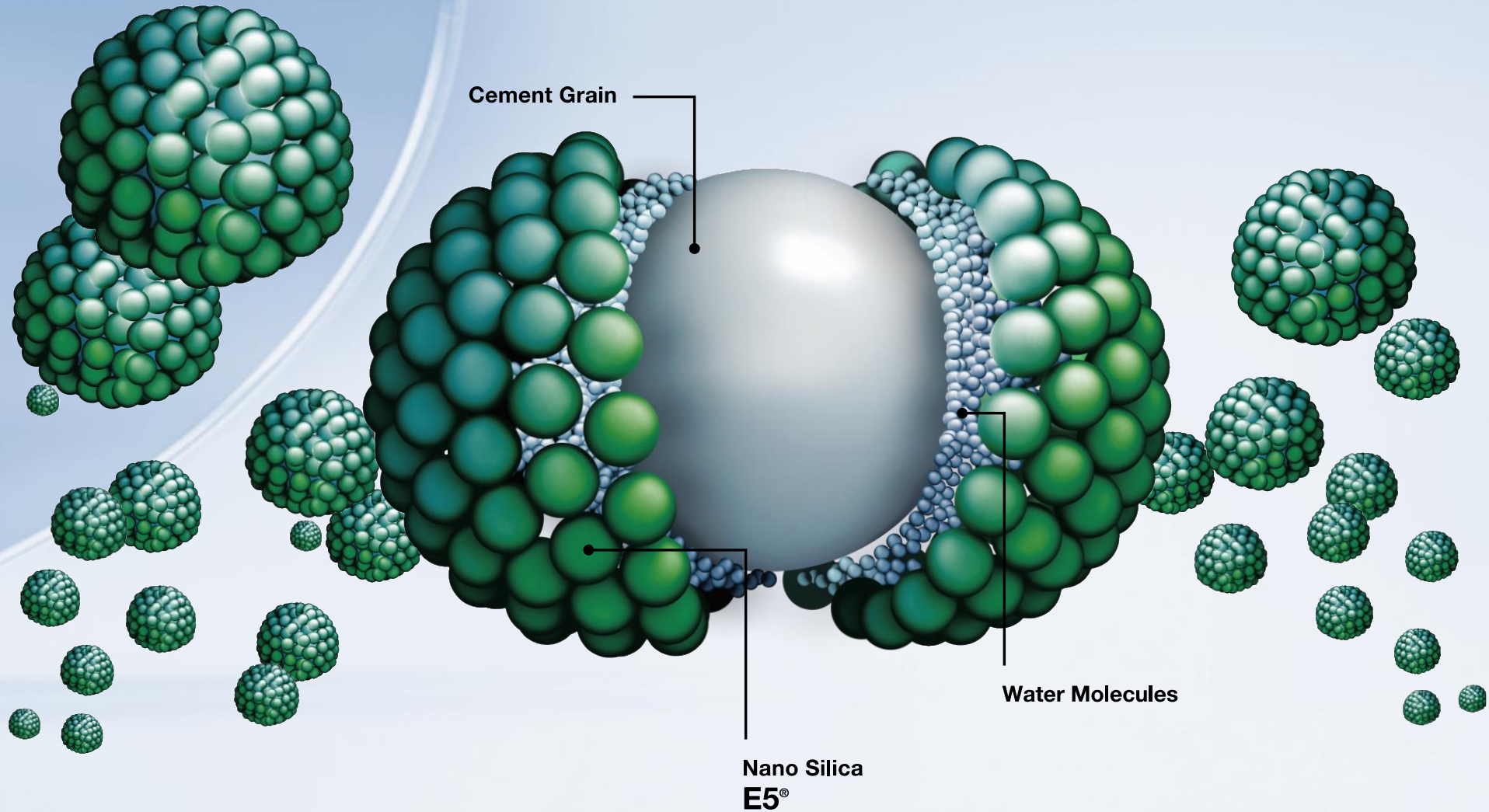
# What is E5 Nanosilica?



## Properties of E5 Nanosilica

- Grown in a reactor
- Perfectly spherical
- > 99% SiO<sub>2</sub>
- Anionic

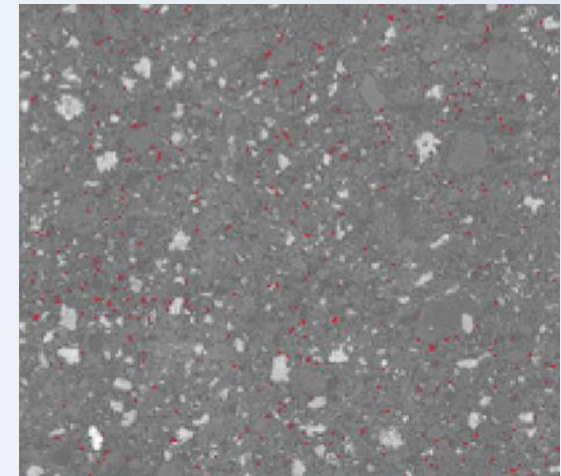
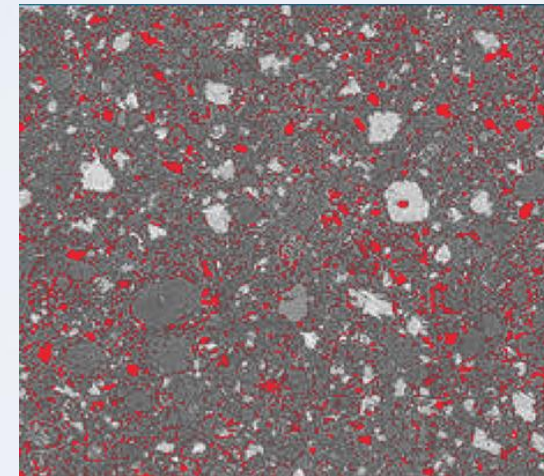
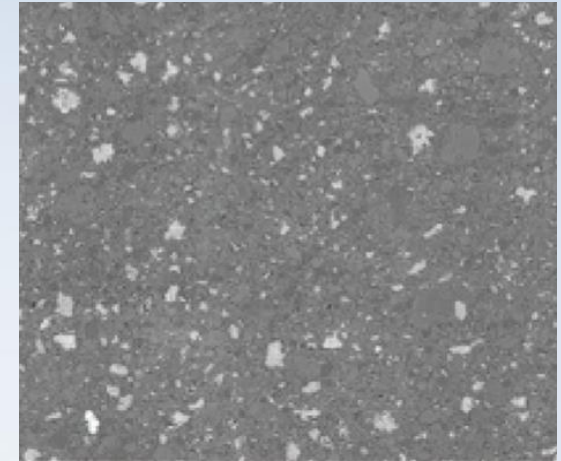
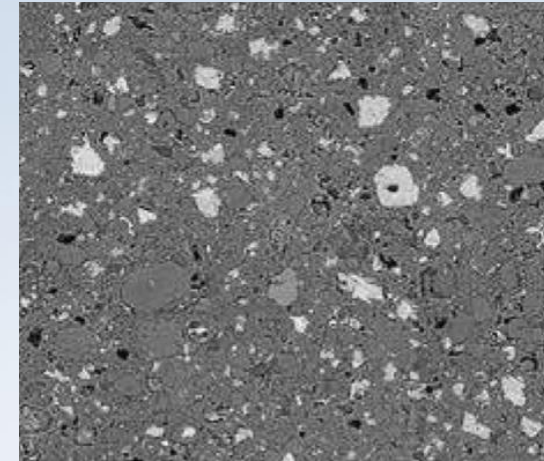
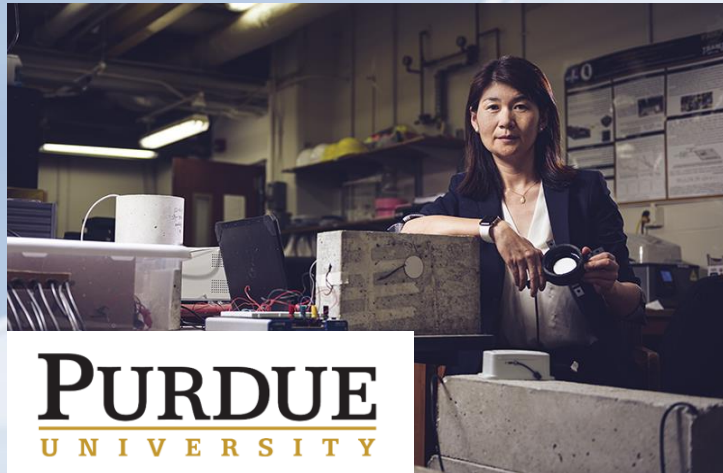
# How does E5 Nanosilica work?



Not to scale

# How does E5 Nanosilica work?

- Increased Cement Hydration
- Petrographic Examination w/ Backscatter Analysis (BIA)
- Red indicates unhydrated cement



Control

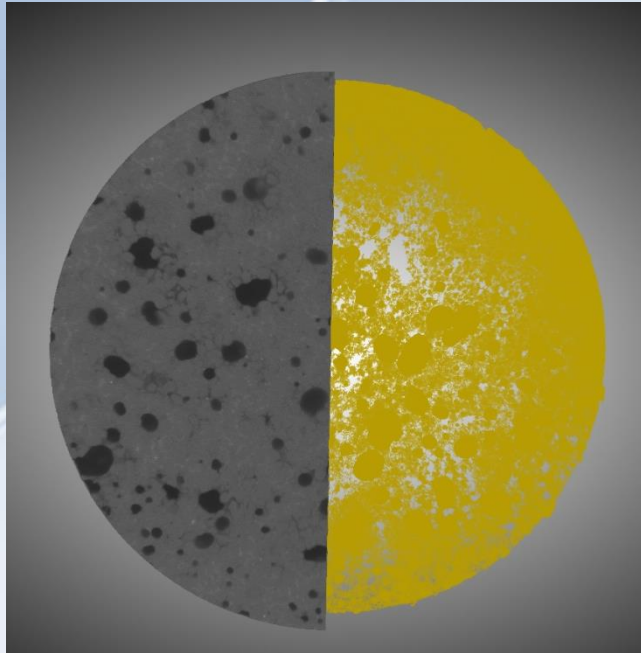
Control + E5 Nanosilica



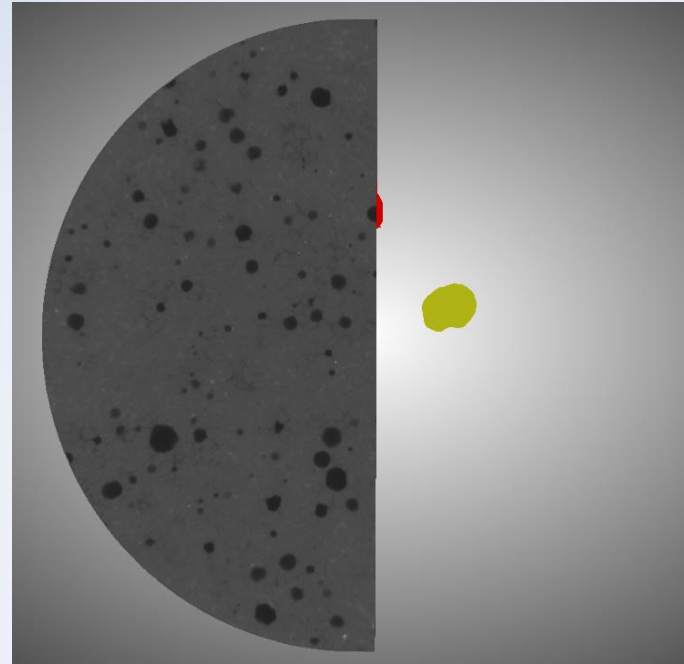
# Micro-CT

Reference **vs** 0.3%E5

Reference



0.3%E5



- The incorporation of the E5 effectively improved the quality of the interface, a less porous interface was observed in the sample with E5.

# Studies / Research

## Published Papers:

Dr. Jason Weiss, Oregon State University & Dr. Jon Belkowitz, Intelligent Concrete

- *Utilizing Nano Silica to Reduce Calcium Oxychloride Formation in Cementitious Materials*  
- Transportation Research Board (TRB), October 2022

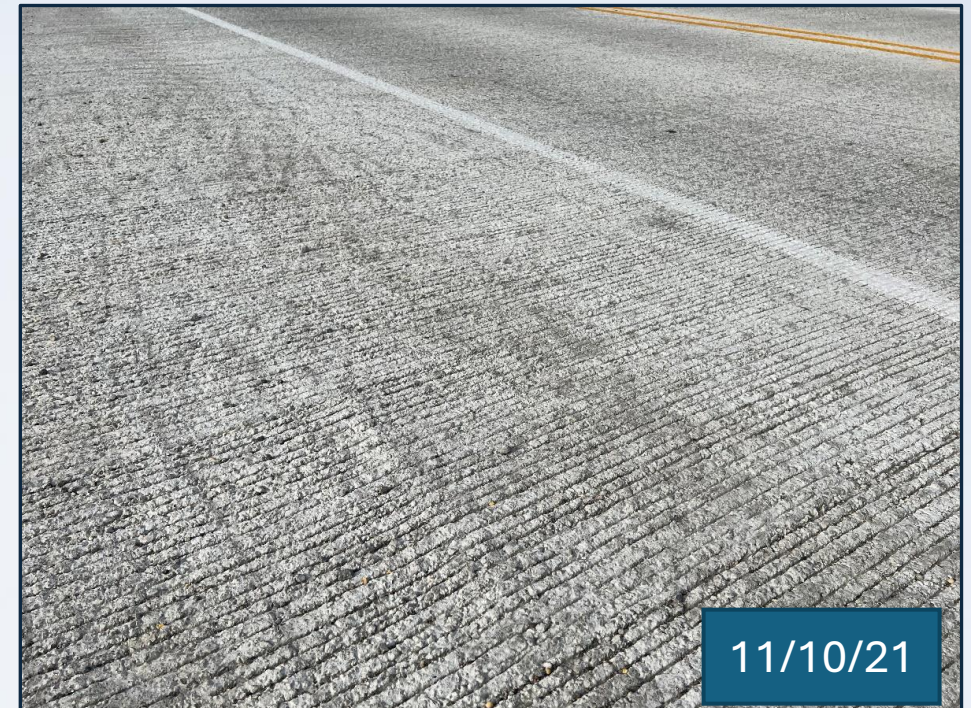
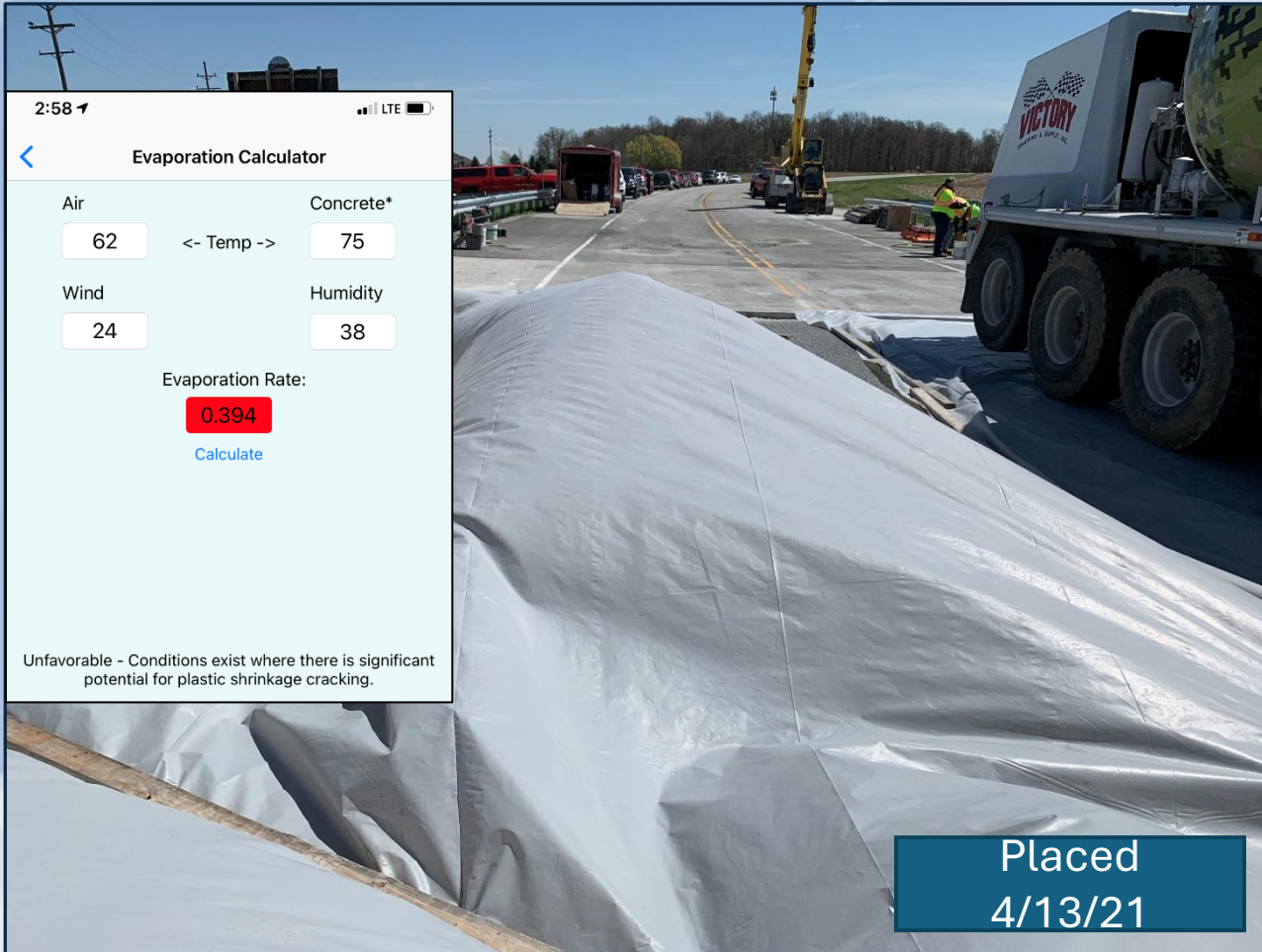
Dr. Na (Luna) Lu, Purdue University

- *Investigation of medium-term self-healing performance of strain-hardening cementitious composites incorporated with colloidal nano silica*  
- Construction and Building Materials, April 2022
- *Investigation of Internal Curing Efficacy of Portland Cement Concrete Incorporated with Colloidal Nano Silica*  
- ES Materials and Manufacturing, December 2022
- *Effect of Colloidal Nano Silica on the Freeze-Thaw Resistance and Air Void System of Portland Cement Concrete*  
- Journal of Building Engineering, February 2024
- *Mitigation Mechanisms of Alkali Silica Reaction Through the Incorporation of Colloidal Nano SiO<sub>2</sub> in Accelerated Mortar Bar Testing*  
- Construction and Building Materials, March 2024
- *Influence of the colloidal nano silica on the bonding of new-to-old concrete interface*  
- Construction and Building Materials, March 2024

# Bridge Deck Overlays

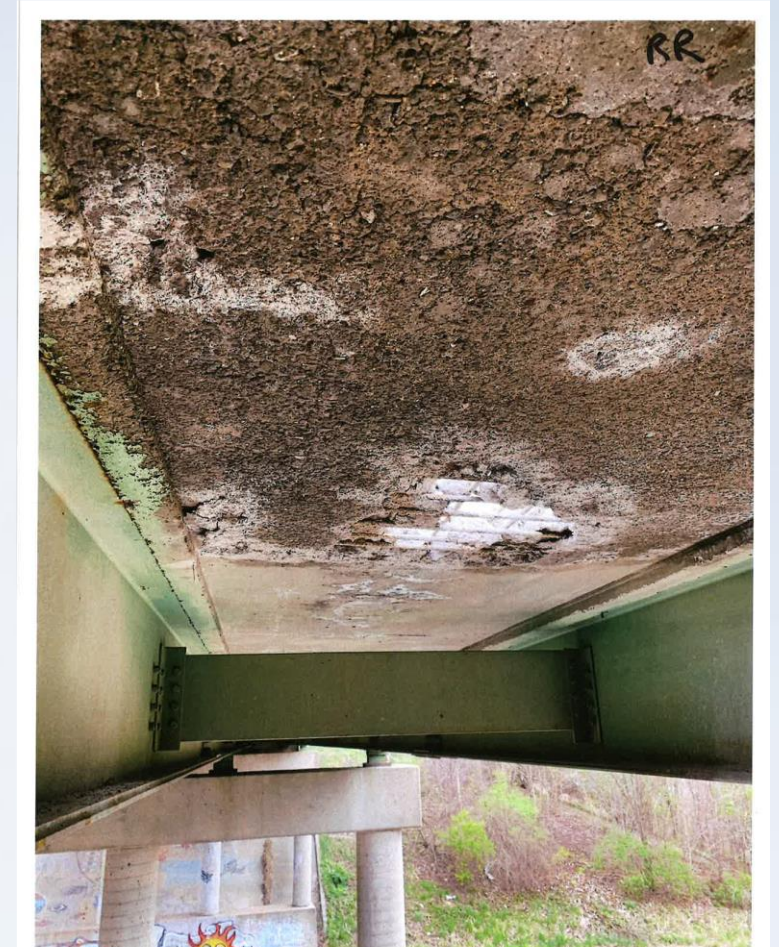
## Mix design

- Cement content 600 pcy
- 4 oz/cwt E5 Plus Internal Cure® admixture
- 8 oz/cwt E5 Liquid Fly Ash® (LFA) admixture
- Fibrillated microfiber
- 0.46 W/C ratio (minimum)
- Traditional water cure & machine grooving



# Bridge Deck Overlays

SR-49 – temporary overlays



# Bridge Deck Overlays

SR-49 – temporary overlays  
NB over Evans St. – no fiber



Pic – March 1, 2022

After approx. 6 months

# Bridge Deck Overlays

SR-49 – temporary overlays

SB over Evans St. – no fiber



Pic – March 1, 2022

After approx. 6 months

# Bridge Deck Overlays

SR-49 – temporary overlays  
NB over RR – fiber



Pic – March 1, 2022

After approx. 6 months

# Bridge Deck Overlays

SR-49 – temporary overlays

SB over RR – fiber

- Minimal cracking
- Worst starting condition





# Bridge Deck Overlays

NB I-469 over Dawkins Road,  
Ft. Wayne, IN

- SFMC (passing ln) – 5/18/21
- E5 (driving ln) – 7/15/21



# Bridge Deck Overlays

## SR 3 over Big Blue River

- Both look good
- Minimal cracking in both
- Shadowing of cracks in SFMC

## Cores

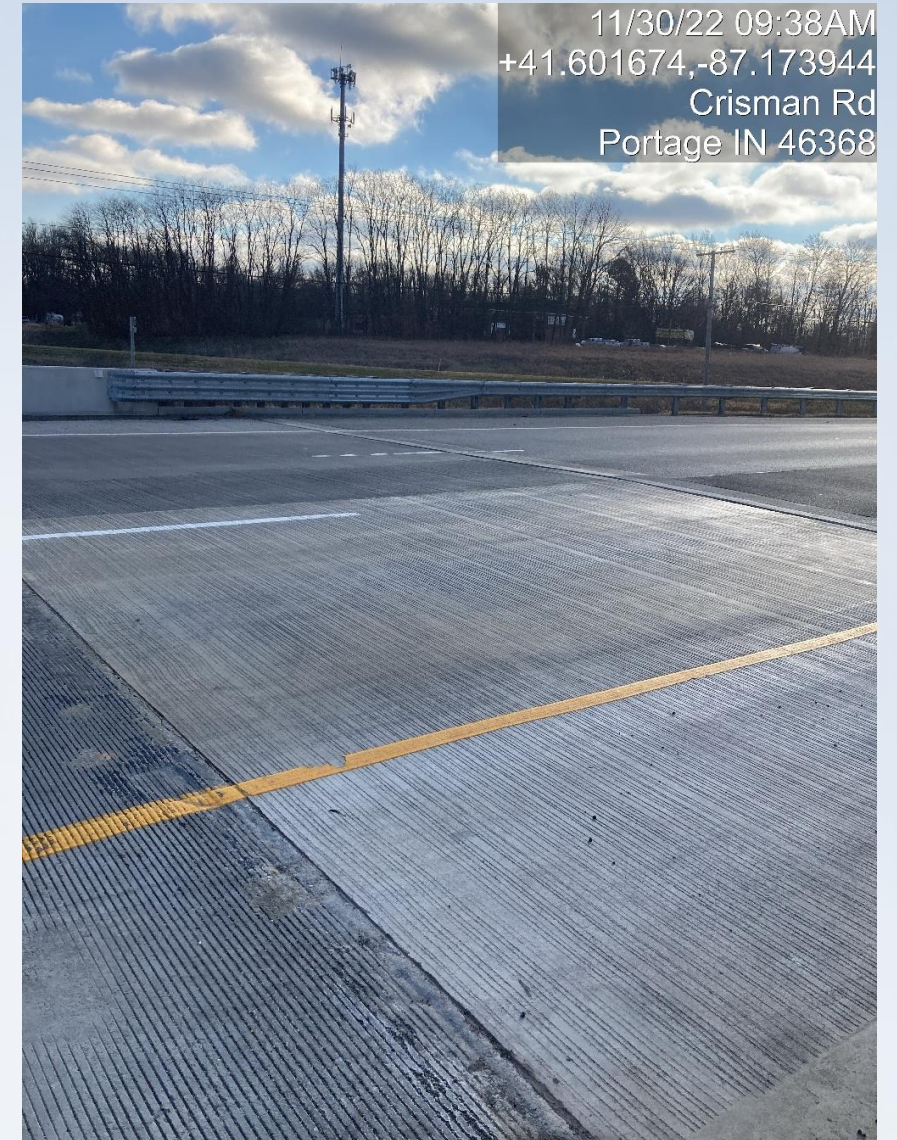
- Bond strength 2 – 2.5x higher



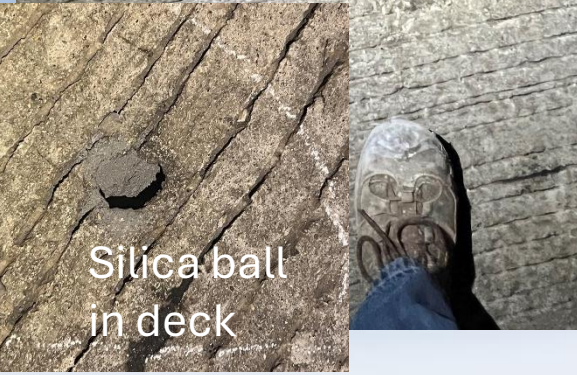
# Overlays

## Dip repair in new approach slab

- SR 249 over I-94
- E5 overlay mix (memo 22-04)
- 3,770 psi @ 28 days
- Placed 7/18/22



# Overlays



E5<sup>®</sup> resolves mixing issues common with bagged silica fume



# Other Uses

Memo 23-01 (superseded by 24-03) formally expanded usage options

- 1 – Decks, RC Slabs, and RCBAs
- 2 – Deck Overlays
- 3 – Bridge/Median railing and Bridge Substructure
- 4 – QC/QA PCCP, Non-QC/QA PCCP, and PCCP Patching
- 5 – Curb, Sidewalks, Ramps, and Driveways

# Memo 24-03



## INDIANA DEPARTMENT OF TRANSPORTATION

100 North Senate Avenue  
Room N758-CM  
Indianapolis, Indiana 46204

[www.in.gov/indot/](http://www.in.gov/indot/)

Eric Holcomb, Governor  
Michael Smith, Commissioner

May 15, 2024

### CONSTRUCTION MEMORANDUM 24-03 (REVISED)

TO: District Deputy Commissioners  
District Construction Directors, Area Engineers, Project Engineers/Supervisors  
Division of Materials and Tests  
District Project Management Directors  
District Technical Services Directors  
District Testing Engineers

FROM: Gregory G. Pankow, Chief Engineer of Construction  
Division of Construction Management and District Support

SUBJECT: E5 Internal Cure and E5 Liquid Fly Ash in Concrete

SUPERSEDES: 23-01

E5 Internal Cure (E5-IC) and E5 Liquid Fly Ash (E5-LFA) by Specification Products are both colloidal silica-based technology for concrete. E5-IC is an admixture that provides improved water retention. E5-LFA is a liquid supplementary cementitious material (SCM). Both products have been shown to provide significant benefits during the placement of concrete and in the overall quality of the in-place concrete. Some of the benefits include improved workability, pumpability, water retention and higher pozzolanic activity, which can create higher strength and reduced permeability.

If the contractor chooses to use E5-IC and/or E5-LFA, both a request and the proposed concrete mix design (CMD) on the Department provided spreadsheet shall be submitted to the Department's project personnel for approval. The request and CMD shall be submitted a minimum of seven days prior to placement. Project personnel will forward the mix design to the District Testing Engineer for review. Upon approval, a zero-cost change order will be processed to add the appropriate contract pay item(s) with a supplemental description as follows:

### Application #3 - Reinforced Concrete Bridge Approach (RCBA), Bridge Railing, Median Barrier Rail, and Substructure Elements

For concrete used in construction of **RCBAs**, bridge railings, median barrier railings, and substructure elements (bents, caps, piers, and footings), the following additional options are available.

E5-LFA may be used as an SCM per 702.05 and 709.05(c) with the following exceptions:

1. Specification Products' representatives are permitted to be on site, but not required.
2. The dosage rate shall be a minimum 8 oz/cwt of cementitious.
3. No other SCMs shall be added.
4. Surface sealing (702.05) shall not be used.
5. For formed concrete the water-cementitious ratio shall be 0.42 to 0.48.
6. For slip-formed concrete the minimum water-cementitious ratio shall be 0.38.
7. Slump (AASHTO T 99) for formed concrete: minimum 3 in., maximum 7 in.
8. A water reducing admixture may be used but is not required for Class A concrete.

E5-IC may be used as the curing method in lieu of the methods in 502.15, 604.03(h), and 605.04(f) with the following exceptions:

1. Specification Products' representatives are permitted to be on site, but not required.
2. The dosage rate shall be a minimum 4 oz/cwt of cementitious.
3. No other SCMs shall be added.
4. For formed concrete the water-cementitious ratio shall be 0.42 to 0.48.
5. For slip-formed concrete the minimum water-cementitious ratio shall be 0.38.
6. Slump (AASHTO T 119) for formed concrete: minimum 3 in., maximum 7 in.
7. A water reducing admixture may be used but is not required for Class A concrete.

The following products may be used:

1. E5 Miracle Aid by Sika
2. The Juice by M2 Solutions.

### Application #4 - QC/QA PCCP, Non-QC/QA PCCP, and PCCP Patching

E5-LFA may be used as an SCM in both binary and ternary mixes per 501.05, 502.04, and 506.04 with the following exceptions:

### Application #5 - Curb, Sidewalk, Curb Ramps, Commercial and Private Driveways

For concrete used in the construction of curb, sidewalk, curb ramps, and commercial and private driveways, the following additional options are available.

E5-LFA may be used as an SCM with the following exceptions:

1. Specification Products' representatives are permitted to be on site, but not required.
2. The dosage rate shall be a minimum 8 oz/cwt of cementitious.
3. No other SCMs shall be added.
4. For formed concrete the water-cementitious ratio shall be 0.42 to 0.48.
5. For slip-formed concrete the minimum water-cementitious ratio shall be 0.38.
6. Slump (AASHTO T 119) for formed concrete: minimum 3 in., maximum 7 in.
7. A water reducing admixture may be used but is not required for Class A concrete.

E5-IC may be used as a curing method in lieu of the methods in 502.15, 604.03(h), and 605.04(f) with the following exceptions:

1. Specification Products' representatives are permitted to be on site, but not required.
2. The dosage rate shall be a minimum 4 oz/cwt of cementitious.

[https://www.in.gov/dot/div/contracts/conmemo/24-03\(revised\).pdf](https://www.in.gov/dot/div/contracts/conmemo/24-03(revised).pdf)



# E5 in Slip Formed Railings



- Increased production ~20%
- Minimal finishing
- Better consolidation
- Better aesthetics

# Questions?

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