



## BRIDGE DECK INNOVATIONS FOR LONGER LIFE CYCLE:

INTERNAL CURE AND LIQUID FLY ASH + CONCRETE SENSORS + TRANSPARENT STAY-IN-PLACE FORMS

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## AGENDA

- INDOT PERSPECTIVE ON BRIDGE DECK TECHNOLOGIES
- TRANSPARENT STAY-IN-PLACE FORMS
- E5 INTERNAL CURE + E5 LIQUID FLY ASH
- SENSORS
- Q&A

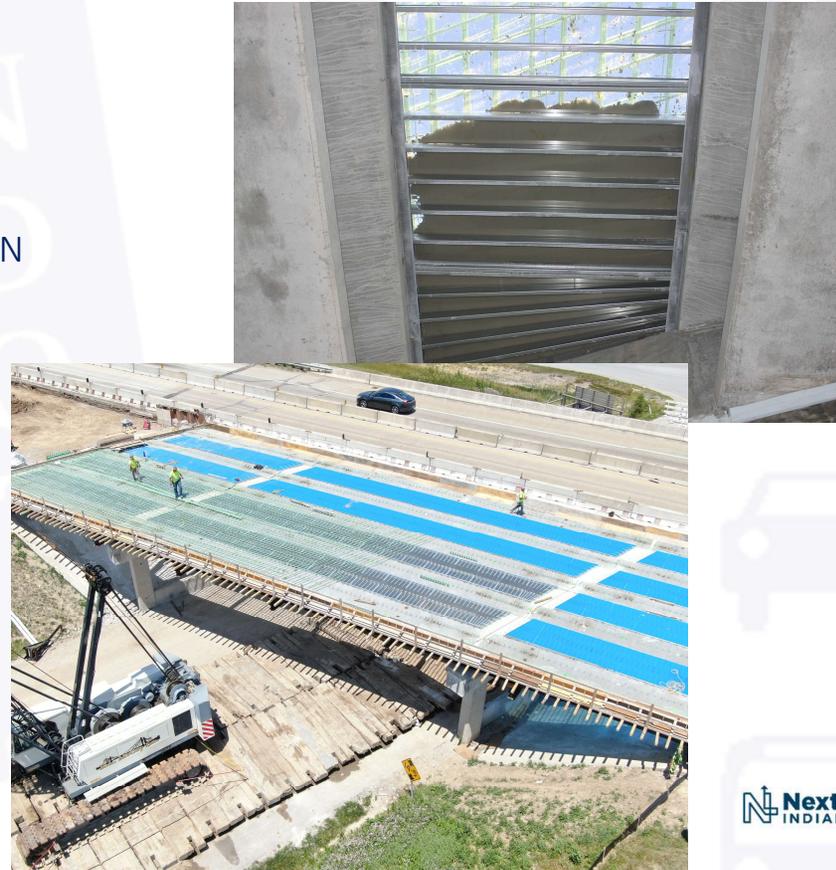
# Transparent Stay-in-place Forms

## INDOT's Usage

- US20 Over I80/I90 in LaPorte, IN
- I-469 Over Lafayette Center Rd. in Fort Wayne, IN
- I-69 Over the Salamonie River in Warren, IN

## Why we like them

- Observe during and after pouring
- Easier to inspect – limits UB inspection
- Contractor's ease of installation



# E5 Internal Cure and E5 Liquid Fly Ash (LFA)

## Full-depth decks

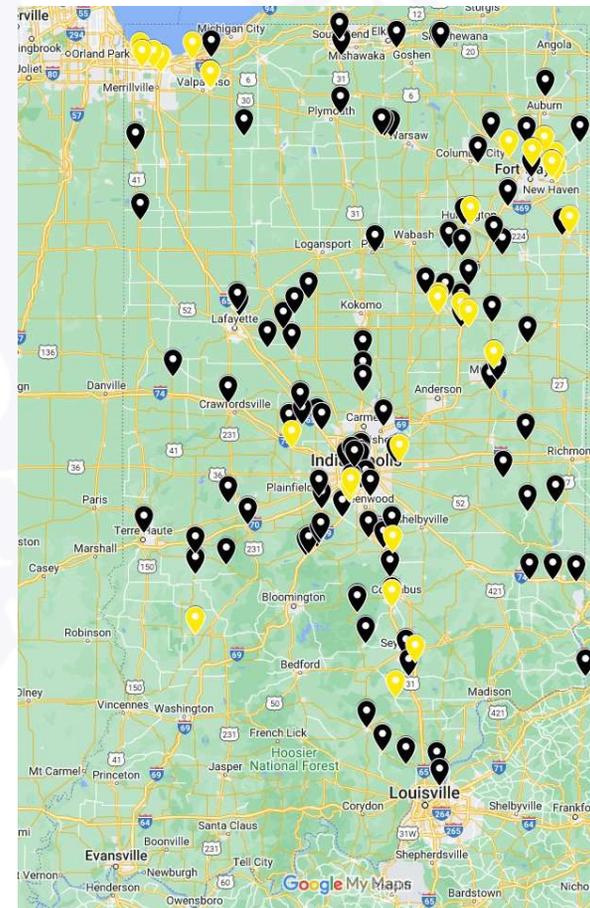
- 202 pours (27 -2020, 46 -2021, 118 -2022, 11 -2023)
  - 2020/2021 – Curing compound only
  - 2022/2023 – Plastic sheeting only
  - 44 pours – E5-IC w/ 3% silica fume
  - 70 pours – E5-IC w/ 30% slag cement
  - 84 pours – E5-IC & E5-LFA (**started in 2022**)

## Deck Overlays

- 3 pours in 2020
  - Added E5 IC to existing SFMC mix (658# cement)
- 44 pours (17 -2021, 23 -2022, 4 -2023)
  - Traditional 7-day wet cure
  - E5-IC & E5-LFA & fiber (no bagged silica)

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

(following slides credited to Michael Nelson, INDOT Concrete Engineer)



- Deck
- Overlay

# E5 in Bridge Decks

## Benefits

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

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

### 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**

Original goal:

Resolve issues behind the screed



# Overlays

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

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



# 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



# Silica issues

Large SFMC popout in full depth deck (2 years old)



EB replaced w/E5

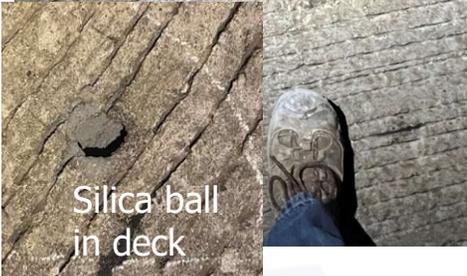
Severe cracks in SFMC overlay after 2 years



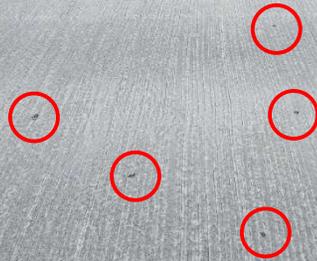
Silica balls in overlay w/ bag fragments



Silica ball in deck



E5 resolves mixing issues common with bagged silica fume



Silica balls/pops in new overlay



Silica balls/pops in new overlay revealed after mill



# E5 Internal Cure and E5 Liquid Fly Ash (LFA)

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## Memo 23-01 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



# E5 in Slip Formed Railings

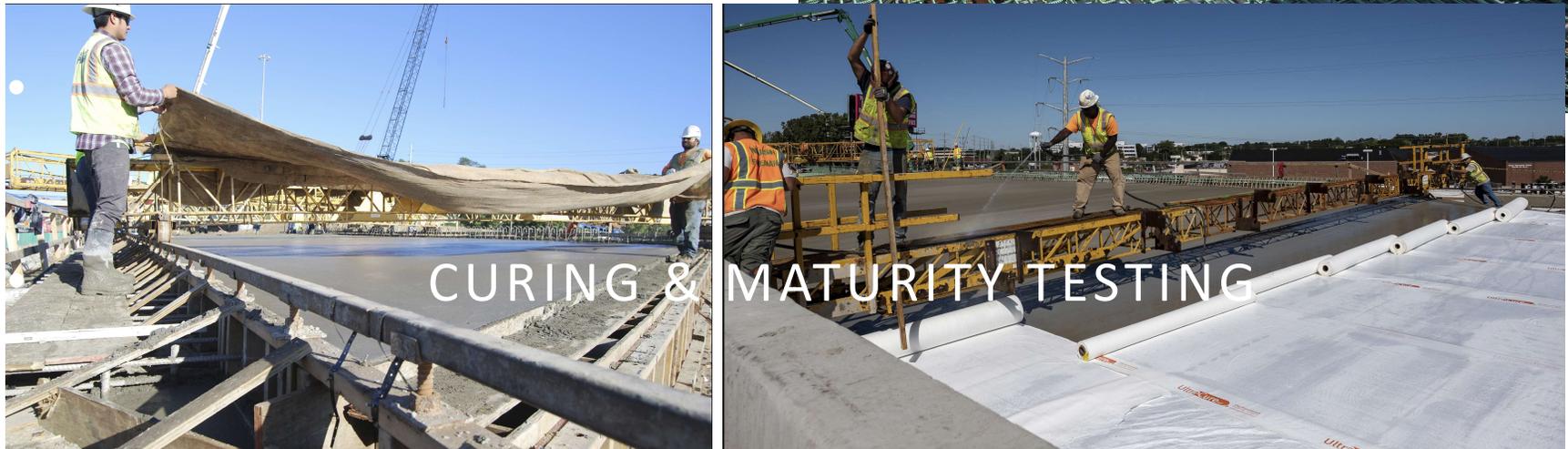


- Increased production ~20%
- Minimal finishing
- Better consolidation
- Better aesthetics

# HOW WE BUILD //



FORMING & PLACEMENT



CURING & MATURITY TESTING

# HOW IMPORTANT IS CONSTRUCTION QUALITY? //

## Concrete Bridge Deck Preservation Resource Guide

### Purpose and Audience

The purpose of this document is to serve as a resource guide listing best practices for concrete bridge deck preservation and to provide links to other available documentation. The intended audience for this guide includes agency bridge planners, designers, project managers, inspectors, maintainers and staff new to bridge deck preservation.

### Importance of Bridge Deck Preservation

Aside from providing the riding surface and being an essential element of the load path, bridge decks act like a roof on a house and provide protection to underlying elements from environmental conditions. Therefore, protecting, preserving and maintaining a bridge deck often correlates to extended service life of the entire bridge.

### Impact of Construction Quality

A good design incorporates measures such as clear cover to reinforcing steel and corrosion resistant reinforcing steel to increase expected longevity of a bridge deck. Construction quality is the first and most salient factor to optimizing service life for a given bridge deck design. It is important to incorporate construction inspection training and robust quality control and quality assurance processes to ensure that the construction methods, materials and placement are in accordance with the plans and specifications. For more information on construction quality, refer to the agency specific material and construction specifications.

### Concrete Bridge Deck Preservation Actions

Bridge deck preservation includes actions or strategies that prevent, delay or reduce deterioration of bridge decks or bridge deck elements in order to maintain or restore the function, keep bridge decks in good or fair condition longer and extend their life. These preservation actions may be cyclic or condition driven and are



# I-469 OVER LAFAYETTE CENTER RD. //



INTERNAL CURE



TRUETECH BRIDGE // [truetechbridge.com](http://truetechbridge.com)



## I-469 OVER LAFAYETTE CENTER RD. //



### Transparent Stay-In-Place Forms

- Allow for consolidation inspection during placement
- Eliminate fall risk during form removal
- Allow for routine inspection of the concrete deck





TrueTech Bridge™

ENGINEERED FOR INTEGRITY

## WHAT OWNERS ARE SAYING...

An added benefit which I had not counted on was being able to see the bottom of the deck during and after the pour. To see that the concrete is mixed well... that there is no segregation of aggregate to the bottom of the forms but a nice slick finish is amazing to see and gives credibility to the assumptions we make of the concrete placement. I am hoping to be able to use these on all of my deck pours in the future.

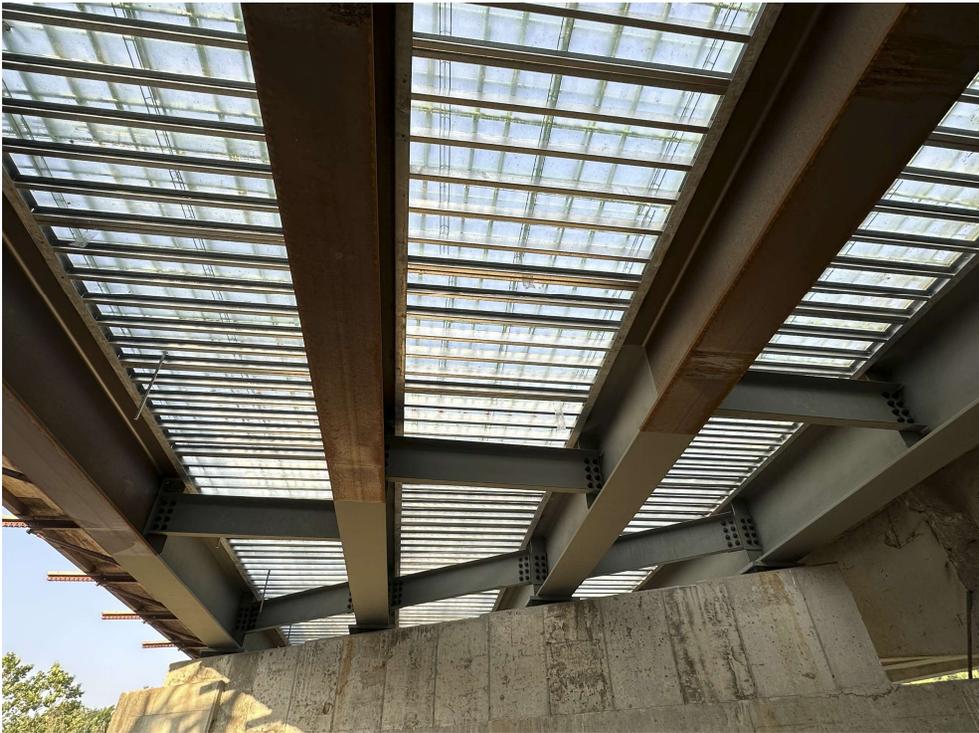
— Keith A. Lytton P.E., Indiana DOT



# DECK QA/QC //



# INDOT 3<sup>RD</sup> PROJECT //



## Nanotechnology – Nanosilica E5 Internal Cure

**E5 Internal Cure®** controls the water, curing the concrete from the inside

- Alternative to 7 day wet cure
- Alternative to using lightweight aggregate for internal curing
- Alternative to spray cure
- Eliminate bleed water
- Improves slump retention
- Eases placement and finishing
- Reduces pump pressure
- Reduces shrinkage
- Improves surface durability



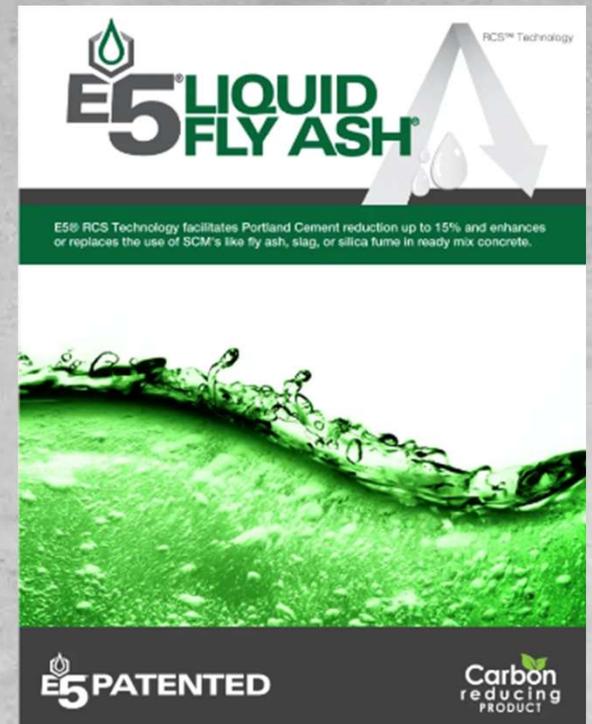
CONFIDENTIAL AND BUSINESS SENSITIVE

# Nanotechnology – Nanosilica

## E5 Liquid Fly Ash

**E5 Liquid Fly Ash®** consumes calcium hydroxide (CH)  
to form new calcium silicate hydrate (CSH)

- Direct replacement for SCMs
- Reduces cement
- Consistent and readily available
- No influence on air content
- Reduces permeability



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# E5 Internal Cure + Liquid Fly Ash

## Indiana DOT – I-469 Bridge Replacement

Material	INDOT Bridge Deck Mix	INDOT E5 Bridge Deck Mix	Improvement by E5
Type I Buzzi Cement (lb/yd <sup>3</sup> )	658	580	12% (< 78 lbs)
Micro Silica (lb/yd <sup>3</sup> )	20	0	3% (< 20 lbs)
E5 Internal Cure (oz/cwt)	0.0	4.0	-
E5 Liquid Fly Ash (oz/cwt)	0.0	8.0	-
w/cm	0.42	0.47	12%
Compressive Strength (lb/in <sup>2</sup> )	6200	6600	6%
Cement Efficiency	9.1	11.4	21%



I-469 EB

Results vary based upon cement, aggregate, and region

Research and Development  
Internal Cure + Liquid Fly Ash



Dr. Luna Lu  
ACPA Professor Lyles School of Civil Engineering  
Director Center for Intelligent Infrastructure  
([luna@purdue.edu](mailto:luna@purdue.edu))

# Research and Development Internal Cure + Liquid Fly Ash

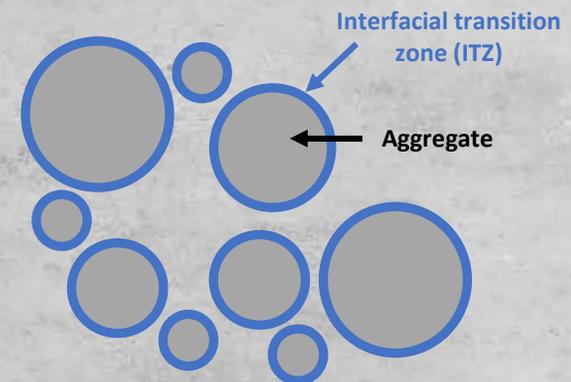
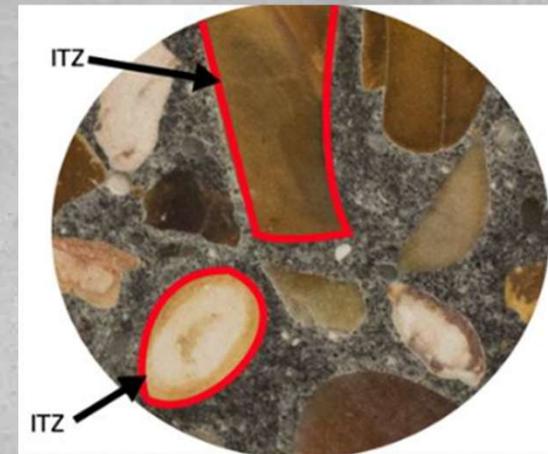


# Research and Development

## Internal Cure + Liquid Fly Ash



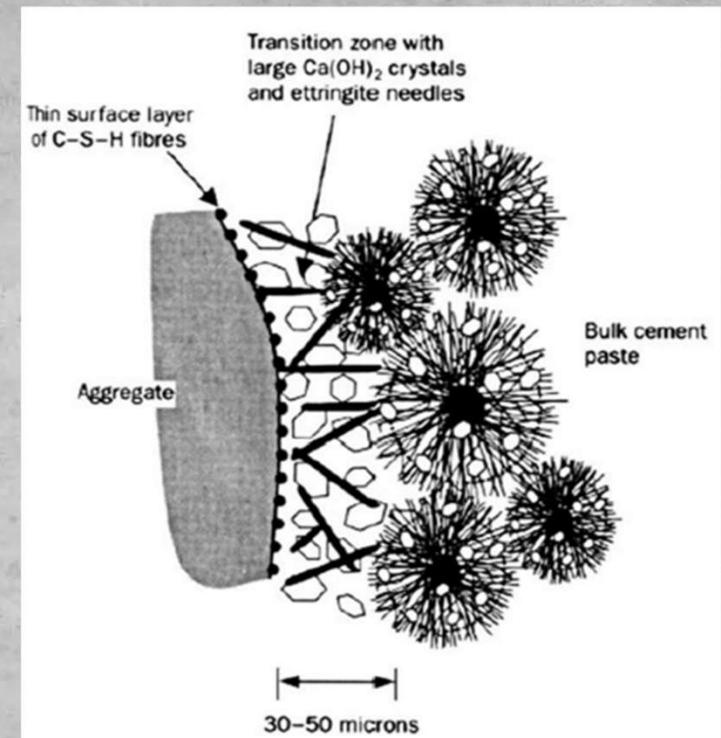
- Dr. Luna Lu points to the 3 phases of concrete
- Coarse Aggregate
- Mortar
- Interfacial Transition Zone (ITZ)
  - significantly higher w/c and excess calcium hydroxide (CH)
  - the weakest link in concrete



## Research and Development Internal Cure + Liquid Fly Ash



- Nanosilica particles are anionic and attach to water
- Excessive water and calcium hydroxide at the ITZ is the ideal location for heterogenous nucleation sites
- Nanosilica consumes the CH to form new CSH



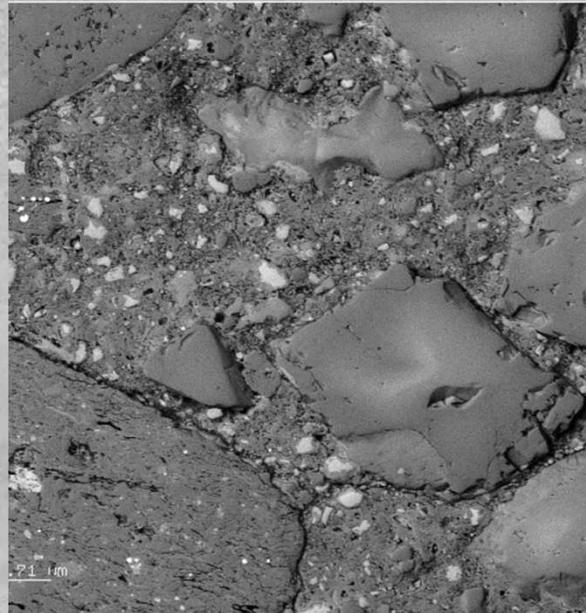
# Research and Development

## Internal Cure + Liquid Fly Ash

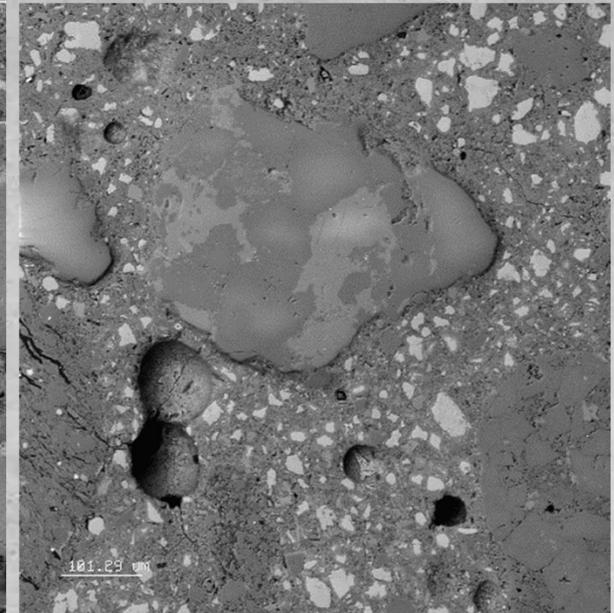


### Improved ITZ:

- Enhances aggregate bond
- Reduces micro-cracking
- Increases abrasion resistance
- Improves concrete ductility



No E5



E5 Internal Cure  
+  
Liquid Fly Ash

# E5 Internal Cure + Liquid Fly Ash

## Indiana DOT – I-469 Bridge Replacement



I-469



# E5 Internal Cure + Liquid Fly Ash

## Indiana DOT – I-469 Bridge Replacement



I-469



## E5 Internal Cure + Liquid Fly Ash Indiana DOT – I-469 Bridge Replacement

### ➤ Non-Destructive Testing Trial

#### ➤ Giatec SmartRock Maturity Sensors

- Monitor time/temperature for strength based upon extensive trial batching

#### ➤ Wavelogix (Piezoelectric) Rebel

#### Concrete Strength Sensors

- Direct in-situ stiffness measured and correlated to compressive strength
- No lab testing necessary to generate curves





## E5 Internal Cure + Liquid Fly Ash Indiana DOT – I-469 Bridge Replacement

### ➤ Water Savings –

➤  $0.60 \text{ gal/ft}^2 \times 14,000 \text{ ft}^2 = 8,393 \text{ gallons}$

### ➤ Cost Savings –

➤  $\$35/\text{yd}^3 \times 480 \text{ yd}^3 = \$16,800$

### ➤ Time Savings –

➤ Accelerated installation and finishing

➤ 7 days of curing

### ➤ Transportation Savings –

➤ Cement and micro silica to concrete plant

➤ Water to job site for wet cure

➤ Reclaimed water away from jobsite

### ➤ Carbon Footprint –

➤ ~43,000 lbs less CO<sub>2</sub>

➤ 37,440 lbs less cement

➤ 9,600 lbs less micro silica



# QUESTIONS?

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