Textured Rebar Update

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Illinois Department of Transportation

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1 What are Textured Rebars?

- According to ASTM A1124 They are:
  - Deformed steel reinforcing bars with protective epoxy coating applied by the electrostatic spray method followed by a texturing surface treatment material.
  - It is not sand or grit…...
- Also Known as TEC Bars

Potential Benefits

2

- For IL DOT – Focus is on Bridge Decks
  - Reduced Cracking and Tighter Cracks
  - Longer Bridge Deck Life
- Also, Shorter “Development Lengths” → Less Rebar Required

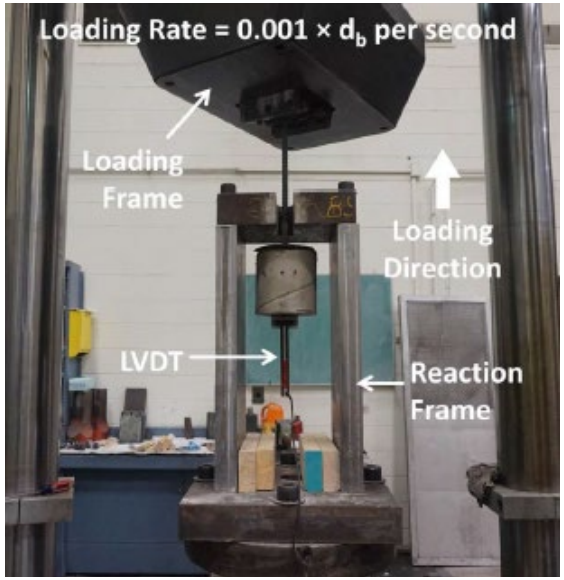
COMPLETED RESEARCH AND DEVELOPMENT EFFORTS

IL DOT Sponsored Research – University of Illinois at Urbana-Champaign - Primary Focus

Other Research – Secondary Focus

3 IL DOT Sponsored Research

- Early Short Special Project
  - Initial Evaluation Included “Pull Out Strengths” for Cylinders and Beams



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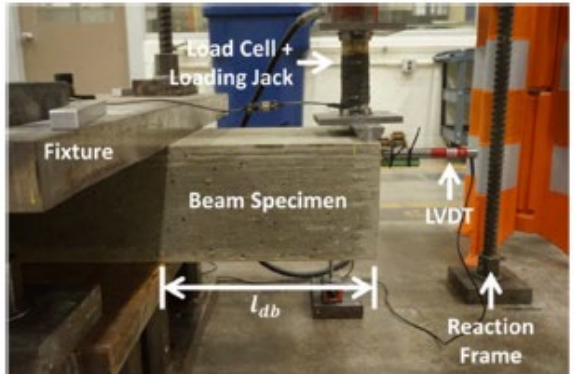
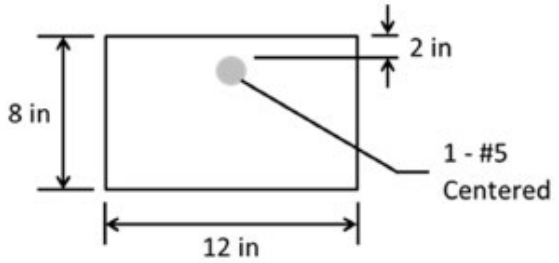
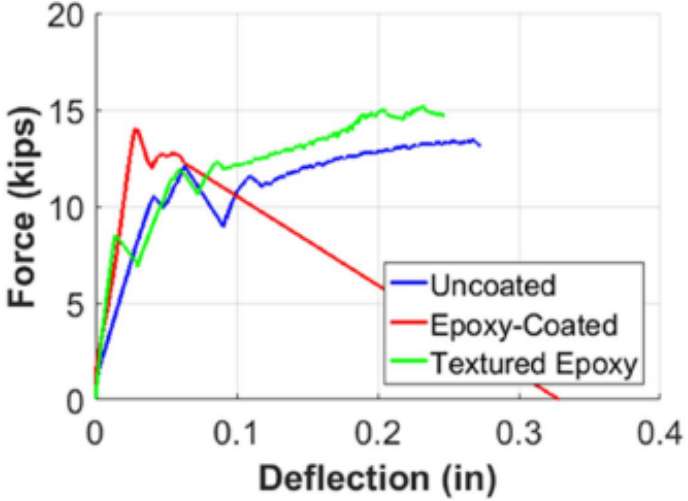
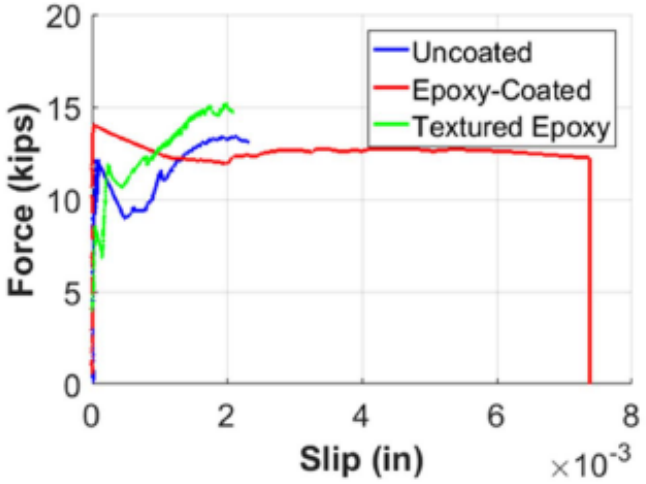
IL DOT Sponsored Research

Beam Specimens







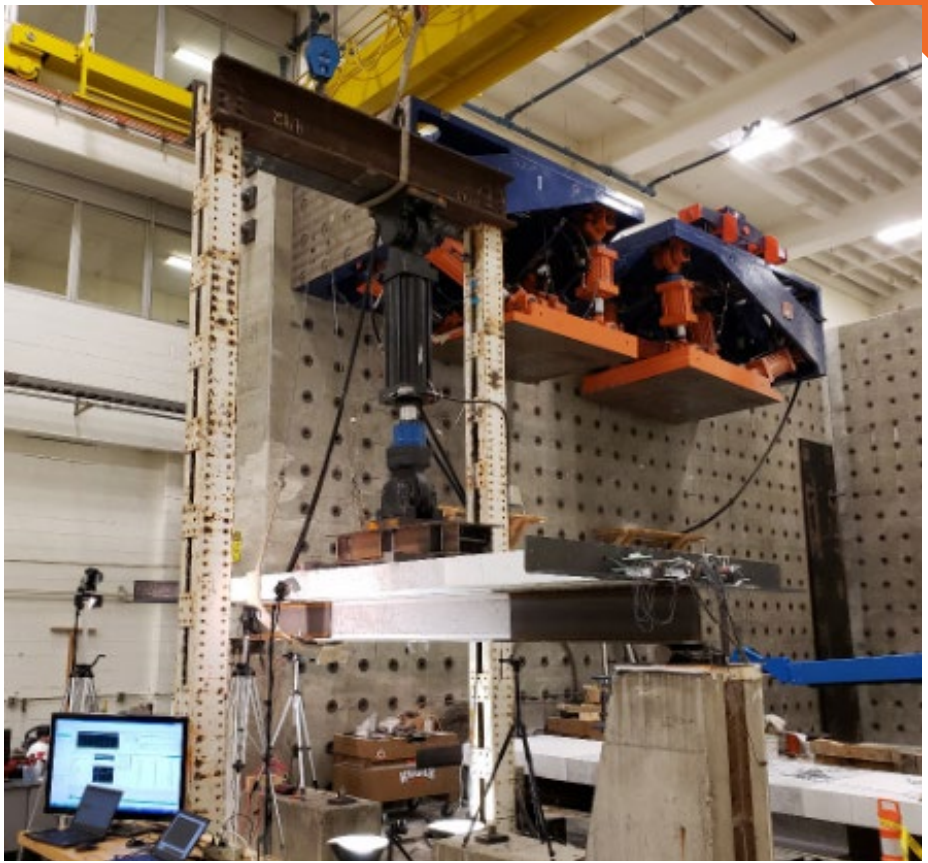


3 IL DOT Sponsored Research

- 1st 3-Year Project
  - Studied such things as:
    - Effect of roughness and surface profile on the bond behavior of TEC rebars.

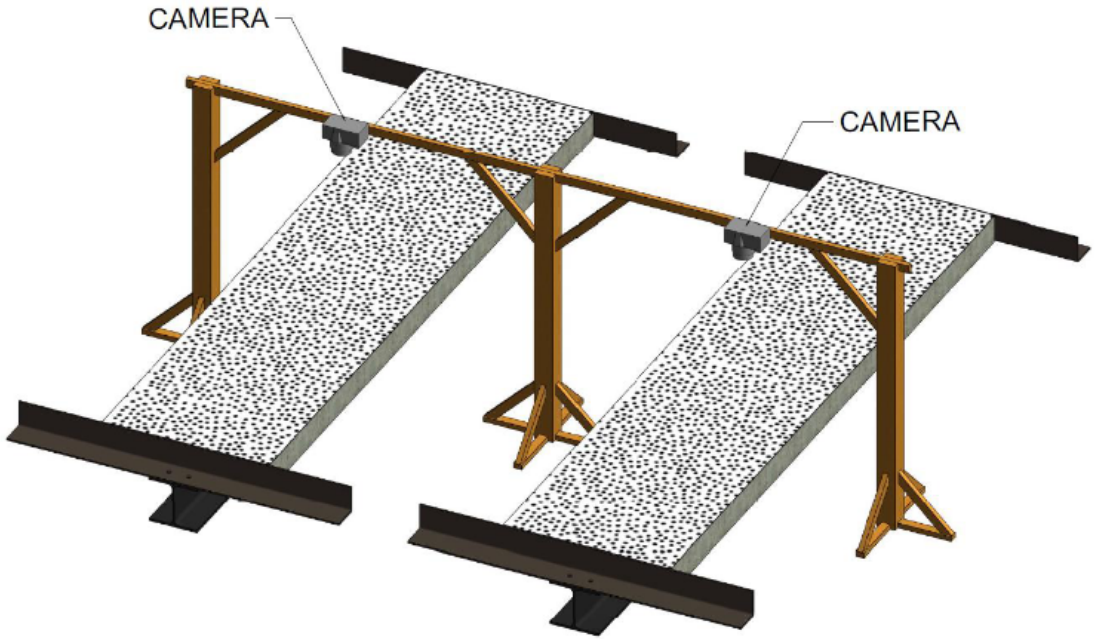
3 IL DOT Sponsored Research

- 1st 3-Year Project
  - Studied such things as:
    - Impact of using TEC rebars on bridge deck crack patterns and at ultimate stages



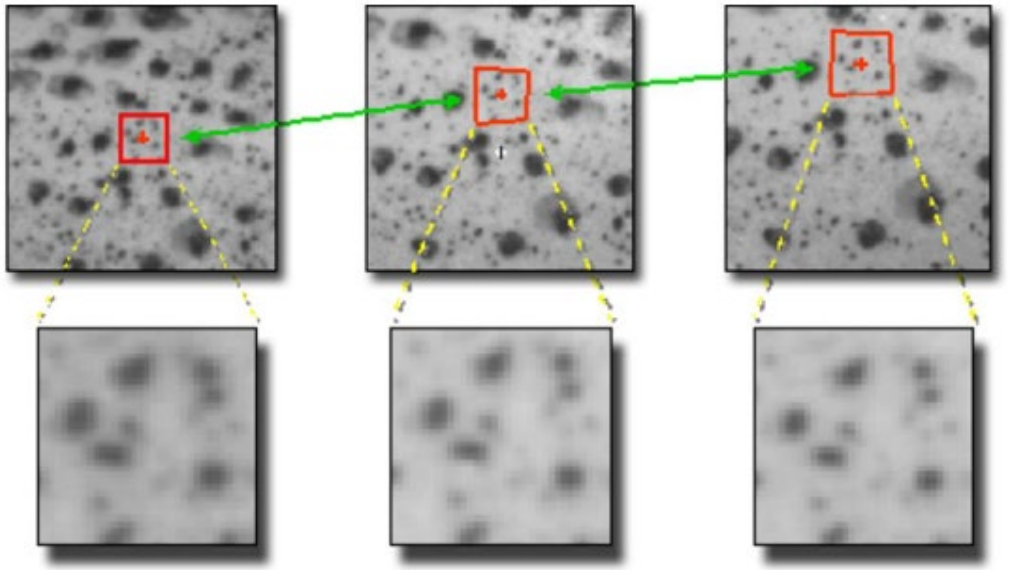
3 IL DOT Sponsored Research

- Bridge Deck Cracking
  - This is very important to IL DOT!



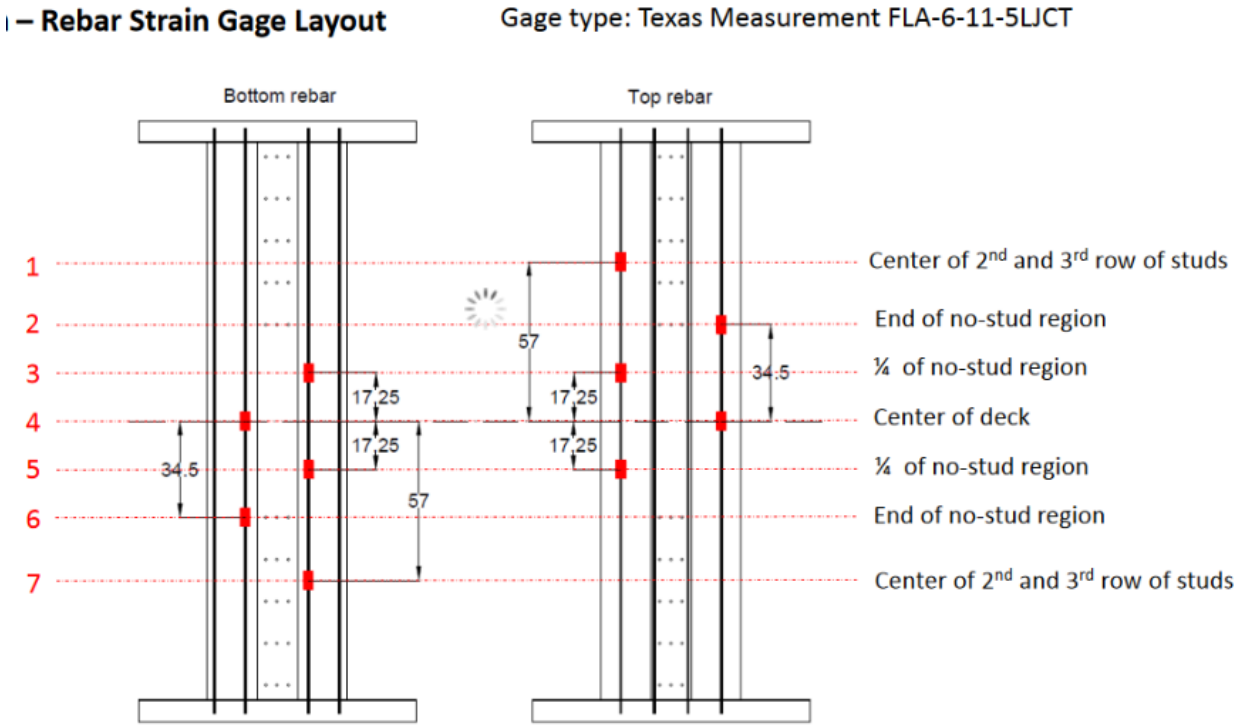
3 IL DOT Sponsored Research

- Digital Image Correlation (DIC)
  - A 2D/3D, full-field, non-contact optical technique to measure contour, deformation, vibration and strain on almost any material by tracking the movement of speckle dots during deformation.



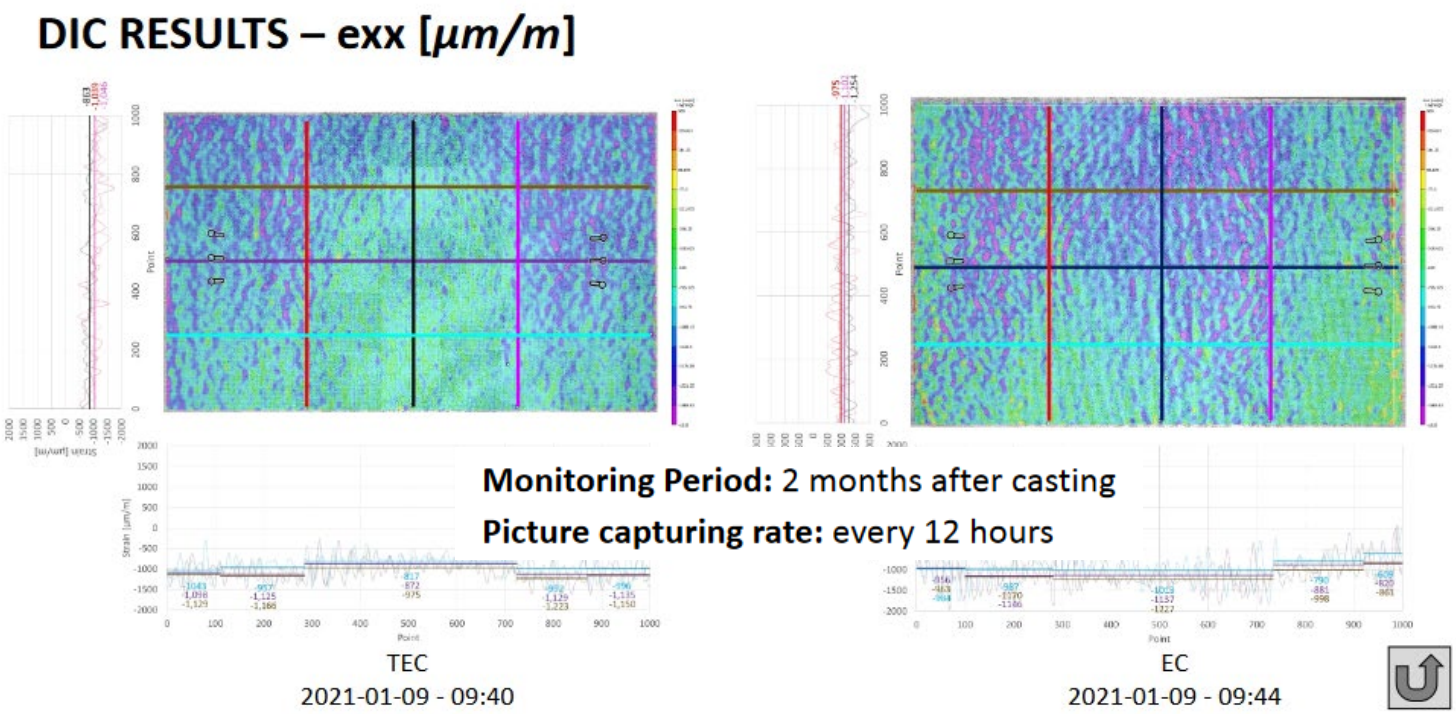
3 IL DOT Sponsored Research

- Conventional Strain Gauges
  - Re-Bar in Simulated Deck Cut-Out



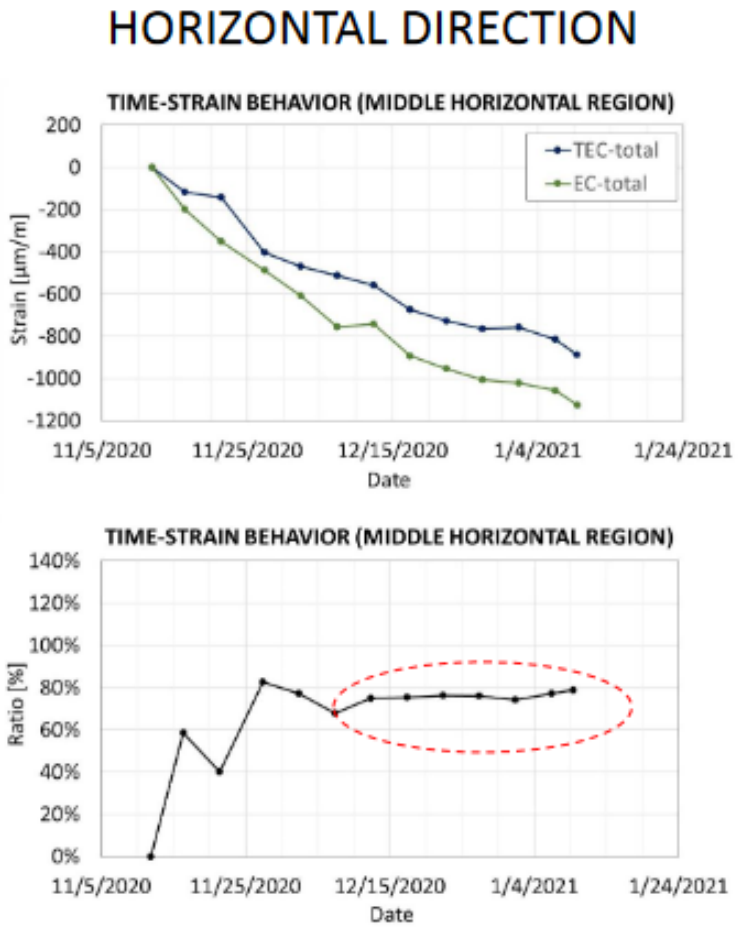
3 IL DOT Sponsored Research

- Shrinkage Testing



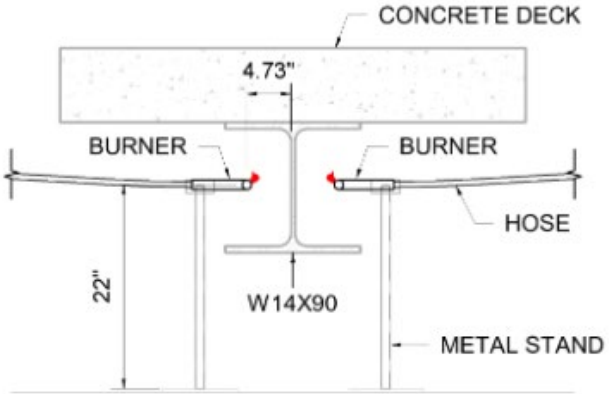
3 IL DOT Sponsored Research

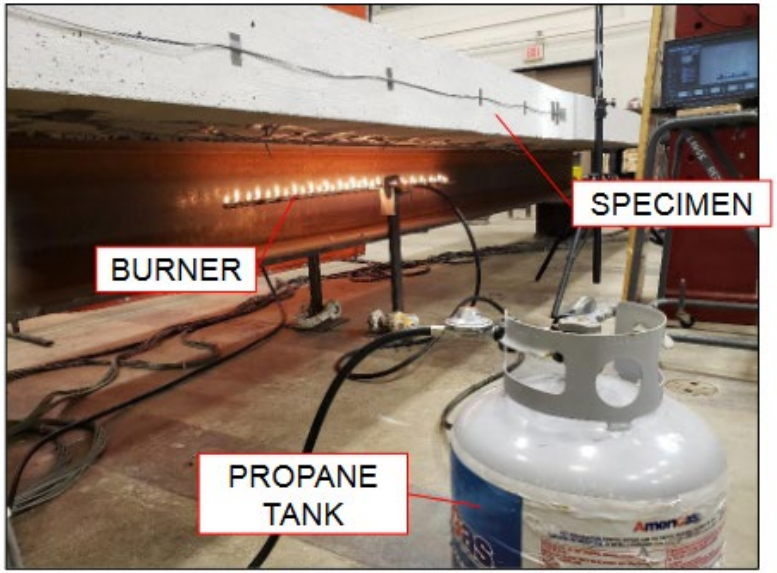
- Shrinkage Testing
  - Horizontal Strain for EC and TEC Bar Decks and the Ratio of TEC to EC Bar Decks



3 IL DOT Sponsored Research

- Temperature Effects Testing

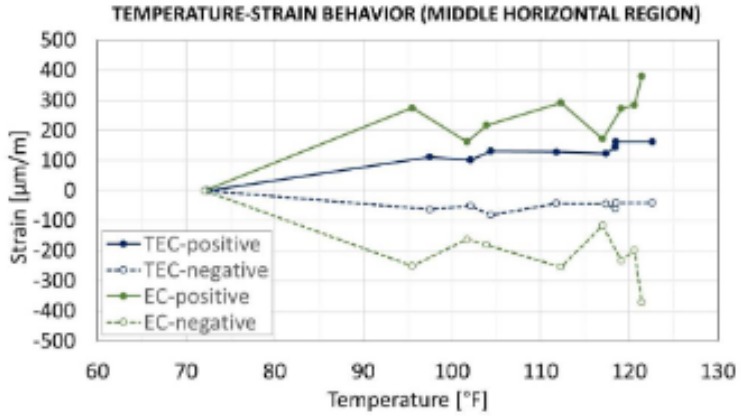


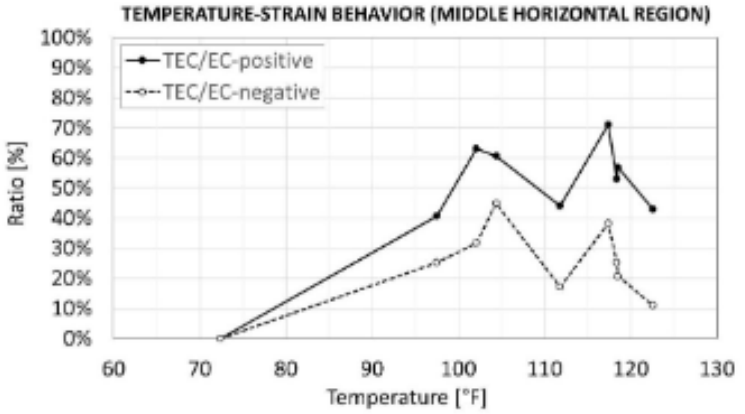


3 IL DOT Sponsored Research

- Temperature Effects Testing
  - Horizontal Strain for EC and TEC Bar Decks and the Ratio of TEC to EC Bar Decks

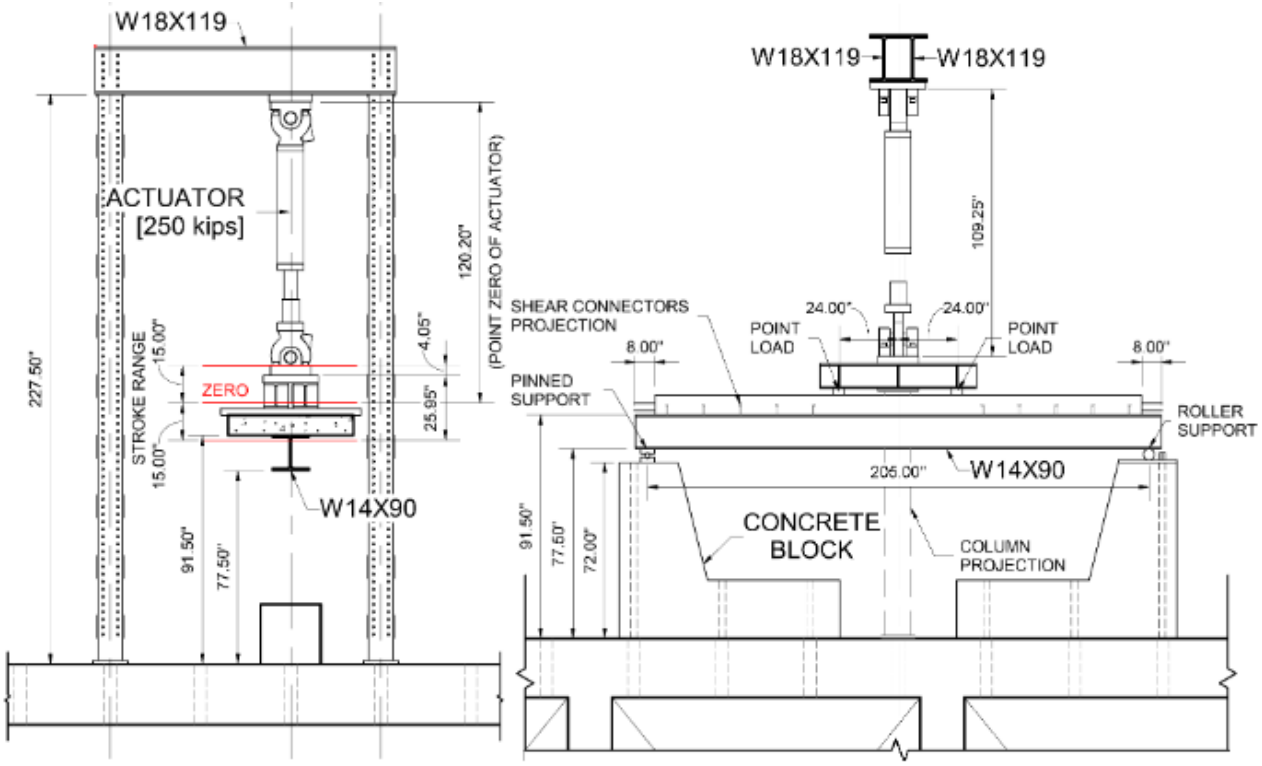
HORIZONTAL DIRECTION





3 IL DOT Sponsored Research

- Flexural Testing

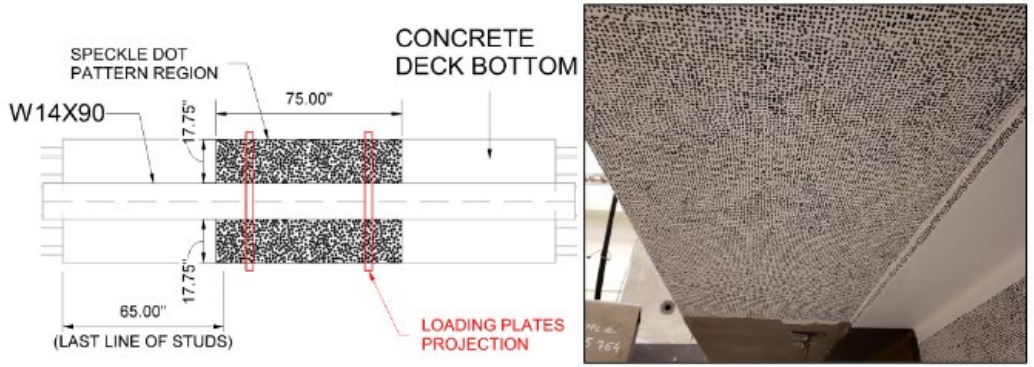


A. Front view.

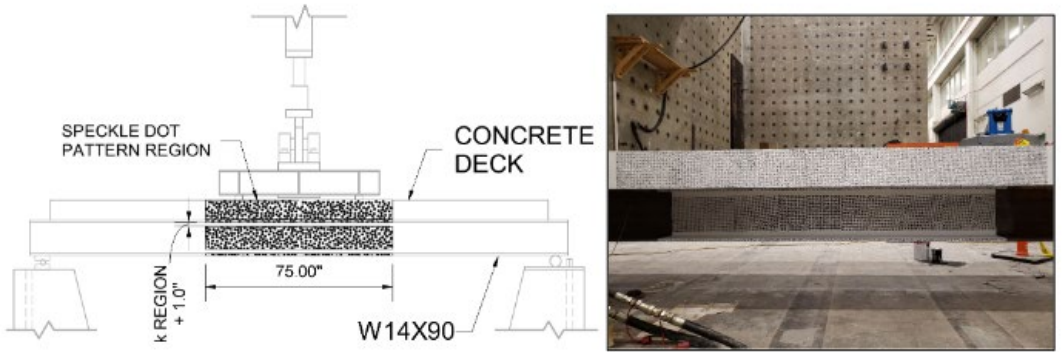
B. Lateral elevation view.

3 IL DOT Sponsored Research

- Flexural Testing
  - DIC Used Again

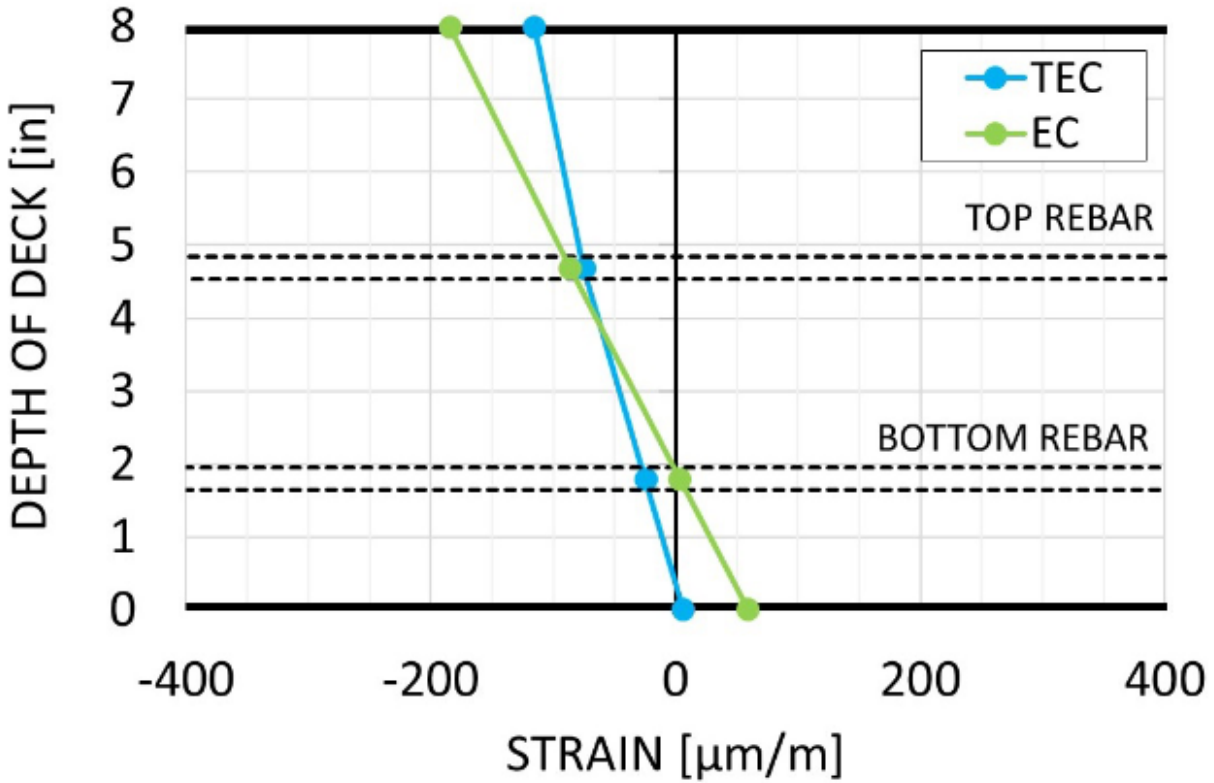


A. Typical diagram for the bottom DIC (left) and applied speckle dot pattern on the underside of the deck (right).



3 IL DOT Sponsored Research

- Flexural Testing
  - Loading is Equivalent to an AASHTO Service Design Load (i.e., Not at Ultimate)
  - Epoxy More Flexible or Less Stiff than Textured



Other Research

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- Other Research Under Ultimate Loadings and Standardized Testing is Also Thought to be Very Significant for the Department
  - Univ. of Kansas Research Under David Darwin and Matt O'Reilly Focused on "Traditional" Testing
  - Brought About ASTM A1124 "Standard Specification for Textured Epoxy-Coated Steel Reinforcing Bars
- Also, Other Research Included that Conducted by the Univ. of Minnesota (very early, I think) and I Believe at Least One Seismic Project

3 Univ. of Kansas Research

- Bond Strength
  - Lap-Splice and ASTM A944 Beam End Testing was Conducted

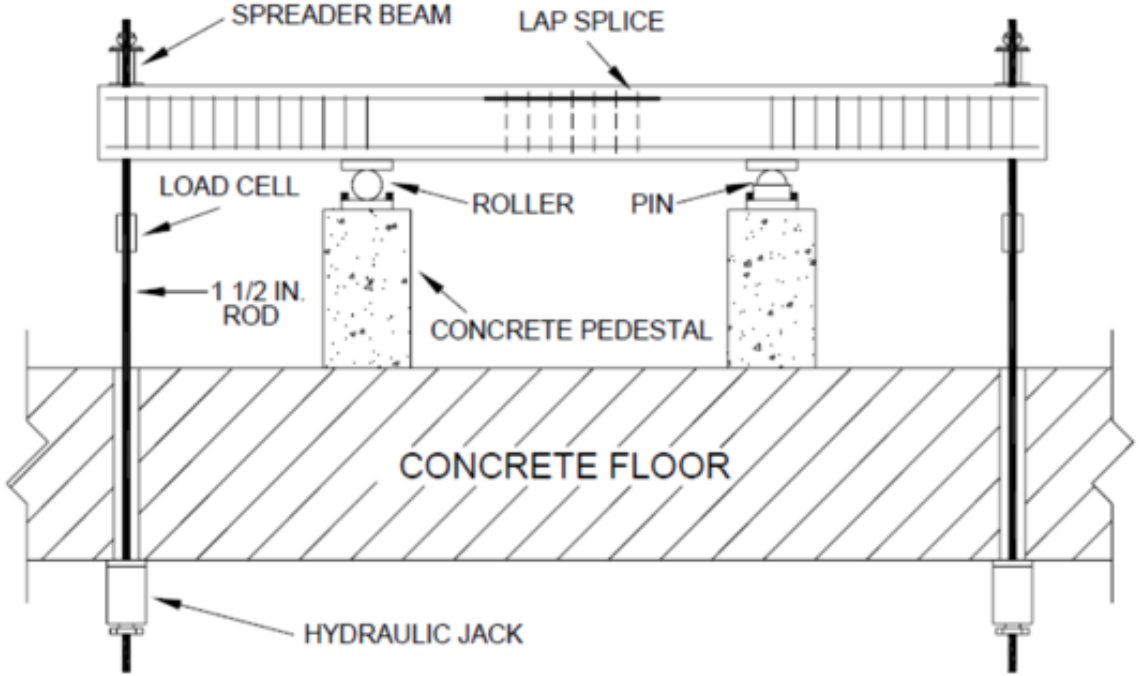

Figure 2: Schematic of lap-splice tests setup.

3 Univ. of Kansas Research

- Bond Strength
  - Lap-Splice – Tech Bars Exhibited Very Good Performance
  - Beam-End – Tech Bars Exhibited Very Good Performance

Table 1: Splice tests and comparison with ACI 408R-03 descriptive equation for uncoated bars **Series**	**Bar Size**	**Bar Surface**	**Stirrups in Splice Region**	**Bar Stress at Failure (ksi)**	**Bond Strength Relative to ACI 408 Equation***
1	No. 11	Uncoated	–	61.0	0.95
		ECR	–	50.8	0.80
		TECR	–	69.2	1.09
2	No. 11	Uncoated	–	69.5	0.83
		ECR	–	60.5	0.70
		TECR	–	83.1	0.94

Table 3: Beam-end test results: Series 1 – Bar force at failure (kips)

	Uncoated	**ECR**	**TECR**
1	23.53	21.32	21.85
2	22.16	*	24.38
3	22.07	19.22	21.10
4	20.76	19.84	20.72
Average	**22.13**	**20.13**	**22.01**
COV	**0.04**	**0.06**	**0.04**
Ratio	**1.00**	**0.91**	**0.99**

University of Kansas Research

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- Other Testing Included:
  - **Taber Abrasion (**ASTM D4060)
    - Determines a coating's performance against erosion, rubbing, scraping, and similar forms of damage
  - **Chip Resistance (**ASTM D3170)
    - Chip Resistance testing is used within the coatings industry to determine resistance of a coating to damage during handling and from stones and similar flying/falling objects
  - **Impact Testing (**ASTM G14)
    - Impact testing is used to determine the resistance of a coating to a rapid deformation event, such as a falling weight

Important Conclusions From Research

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- Univ. of Kansas Research Showed that TEC Bars Behave Comparably to Black Bars (Especially Bond Strength) and the Coating is Comparable to Regular Epoxy (I.e., durability, et al.)
- IL DOT Sponsored Research
  - TEC bars used in this study generally manifested higher initial slip resistance than UC and EC bars
  - Flexural tests demonstrated that TEC bars possessed significantly higher resistance to crack widening
    - Width of the cracks was as low as 50% of that of the specimen reinforced with EC bars
  - DIC contour plots demonstrated a **reduction of 25% in the strain** of Concrete using TEC vs EC bars

CURRENT RESEARCH AND DEVELOPMENT EFFORTS

Long Term Fatigue Testing

Resistance to Corrosion

4 Long Term Fatigue Testing

- We Know TEC Bars Hold Cracks Tighter and Engage Better With the Concrete
- However, Can They Sustain This Under Repeated or Fatigue Loadings?
  - Just like a real bridge experiences……..

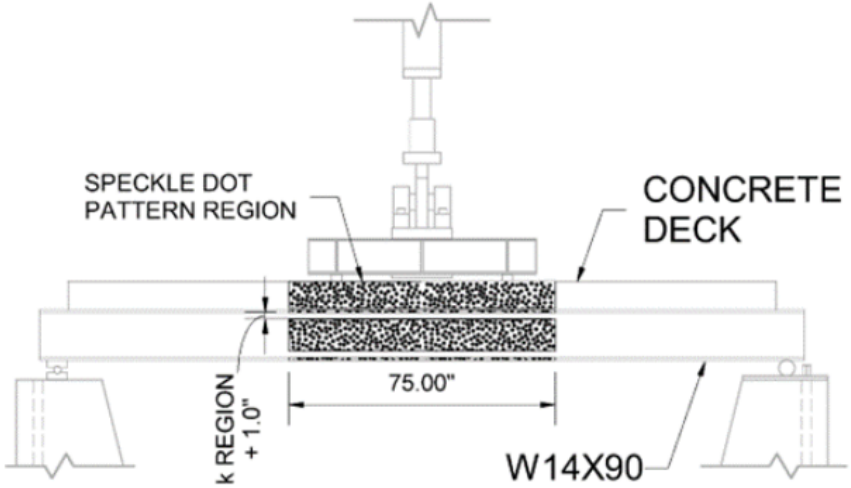


Figure 4. Schematic of bridge deck specimen used for fatigue testing

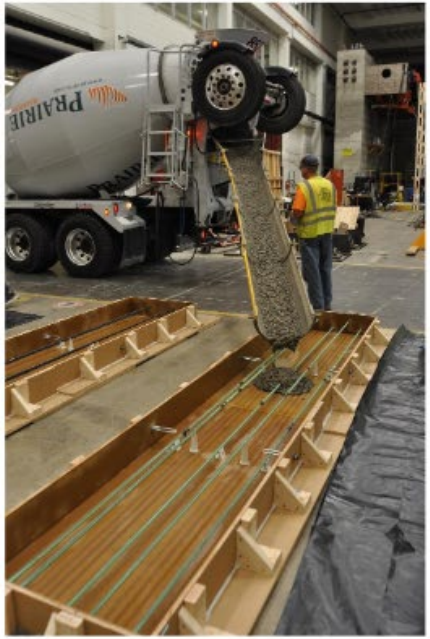
4 Long Term Fatigue Testing

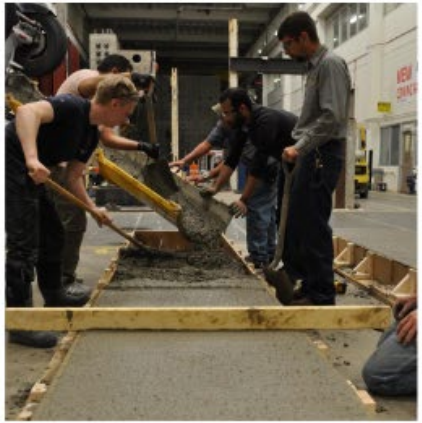
ILLINOIS CENTER FOR TRANSPORTATION

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Illinois Department of Transportation

2. TASK 3: CONSTRUCTION OF DECK SPECIMENS (CASTING)

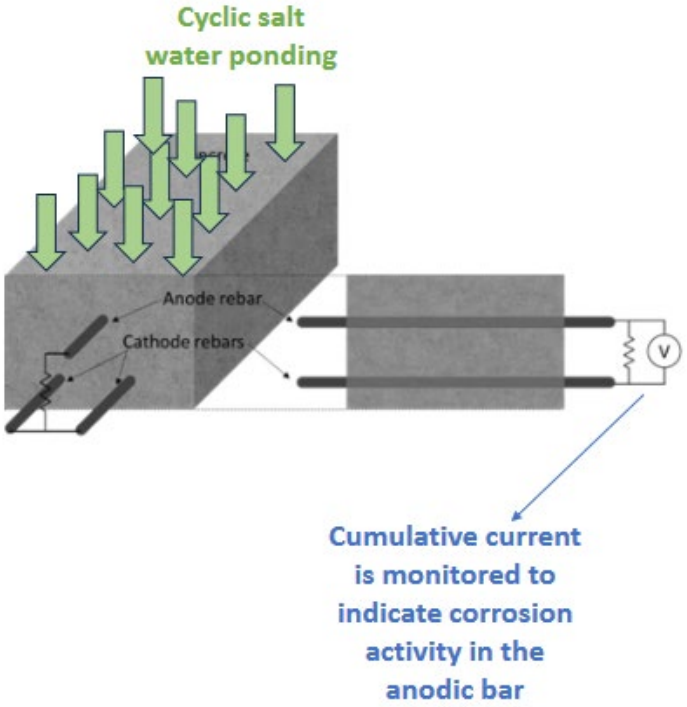




4 Corrosion Resistance

- Is the Corrosion Resistance of TEC Bars Comparable to that of EC Bars??
- Does the Surface Texture Itself Act to Disrupt Protective Coating when Bars are Activated by Load?

ASTM G109 macrocell test configuration



4 Corrosion Resistance

- The Bars are “Cooking”!
- All 60 G109 samples have been cast and are now being exposed to cycles of chloride solution ponding and regular corrosion current measurements for about 3 months.
- 12 Months to Go!

FUTURE IMPLEMENTATION PLANS

Plant Certification Program

Long Term Cost Comparison Bar Selection Criteria

Plant Certification Program

5

- Assuming the Latest Round of Research Pans Out, IL DOT Will Establish a Plant Certification Program
  - CRSI Developing/Developed a Program as Well
- AASHTO Product Evaluation and Audit has a Plant Certification Program for Black Bars Already
  - Modeled After the Existing IL DOT Plant Certification Program
  - IL DOT is the Testing Lab for AASHTO as Well
- However, There is No AASHTO Program for Epoxy Bars
- It Just So Happens, Though, that the IL DOT has Its Own Epoxy Coating Plant Certification Program

5 Plant Certification Program

- IL DOT Plans to Establish a Plant Certification Program Based On the Model of Its Current Epoxy Coating Plant Certification Program

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: May 8, 2024 24-08.7
This Policy Memorandum supersedes number 24-08.6 dated February 6 2020

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION AND EPOXY COATING PRODUCERS

SUBJECT: EPOXY COATING PLANT CERTIFICATION PROCEDURE

1.0 PURPOSE

1.1 To establish procedures whereby epoxy coated steel reinforcing bars, dowel bars, **WWR** and/or **Accessories** furnished by a **Manufacturer** or **Supplier** will be accepted for use

5 Long Term Cost Comparison Bar Selection Criteria

- The Table has Not Currently Been Implemented by IL DOT
- It Should be Considered Preliminary

Table 3. Breakdown of Calculation for Material and Repair Costs over a 100-Year Service Life

Bar Type	Initial Cost ($/0.84m^2) [$/yd^2]	Repair Event Number					Unit Material Repair Cost ($/0.84m^2) [$/yd^2]
		1	2	3	4	5	
		Time to Repair (Years)					
Black Bar*	$1.00	24.33	48.63	72.98	85.20	96.10	$1.00
Epoxy Coated*	$1.10	49.45	85.20	x	x	x	$1.06
TEC	$1.26^	56.87†	97.98†	x	x	x	$1.06
Stainless Steel*	$3.97	x	x	x	x	x	$0.00
SS-CCC	$2.60^	x^	x^	x^	x^	x^	$0.00

*Costs for these bar types were calculated in the final report for R27-SP49 (Gombeda et al., 2022).

^Adopted from Clemeña et al (2003).

†Adopted from Ross et al (2021).

5 Long Term Cost Comparison Bar Selection Criteria

- The Table has Not Currently Been Implemented by IL DOT
- It Should be Considered Preliminary

Table 4. Calculation of Estimated Theoretical and Simplified Life-Cycle Costs

Bar Type	Initial Cost ($/0.84m^2) [$/yd^2]	Material Repair Cost ($/0.84m^2) [$/yd^2]	Estimated Theoretical Material Life-Cycle Cost ($/0.84m^2) [$/yd^2]	Simplified Life-Cycle Cost		
				50-Year Life Cycle	75-Year Life Cycle	100-Year Life Cycle
Black Bar*	$1.00	$1.00	$2.57	$3.00	$4.00	$6.00
Epoxy Coated*	$1.10	$1.06	$1.69	$2.15	$2.15	$3.21
TEC	$1.26	$1.06	$1.76	$1.26	$2.32	$3.37
Stainless Steel*	$3.97	$0.00	$3.97	$3.97	$3.97	$3.97
SS-CCC	$2.60	$0.00	$2.60	$2.60	$2.60	$2.60

*Costs for these bar types were calculated in the final report for R27-SP49 (Gombeda et al., 2022).

Comments or Questions

Daniel H. Tobias, NC^2 Spring 2025, Chicago, IL

Illinois Department of Transportation