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CONCRETE REPAIR
Restore | Repurpose | Renew

2024 SPRING CONVENTION

APRIL 21-24, 2024
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Investigation and Repair of Concrete Bridge Decks

Stephen Garrett, PE

The challenges facing our transportation infrastructure must be met with a rigorous, proactive approach to evaluate in-service conditions and develop optimal preservation and rehabilitation programs. To cost-effectively re-build, rehabilitate, or simply maintain these in-use systems, an inspection approach must consider the uniqueness of each system's construction and exposure.

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Authors

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Acknowledgments

- The following agencies supported the projects and research discussed in this presentation
  - Illinois Department of Transportation
  - Iowa Department of Transportation
  - Indiana Toll Road Concession Company (ITRCC)
  - Federal Highway Administration
  - Pooled fund study TPF-5(474) TAC: IA, IN, MN, MO, NM, TX DOTs and FHWA

Outline

- Introduction
- Basic Inspection Framework
- Advanced/In-depth Inspections
- Service Life Modeling and LCCA
- Case Study – Recent Trends in Bridge Rehabilitation

New Construction

- Material selection and detailing to achieve target service life (50, 75, 100+ years...)
  - Corrosion Resistant Reinforcement (e.g., alloyed and/or coated steels or non-ferrous rebar)
  - Sacrificial Wearing Course, Material Type, Maintenance Plans

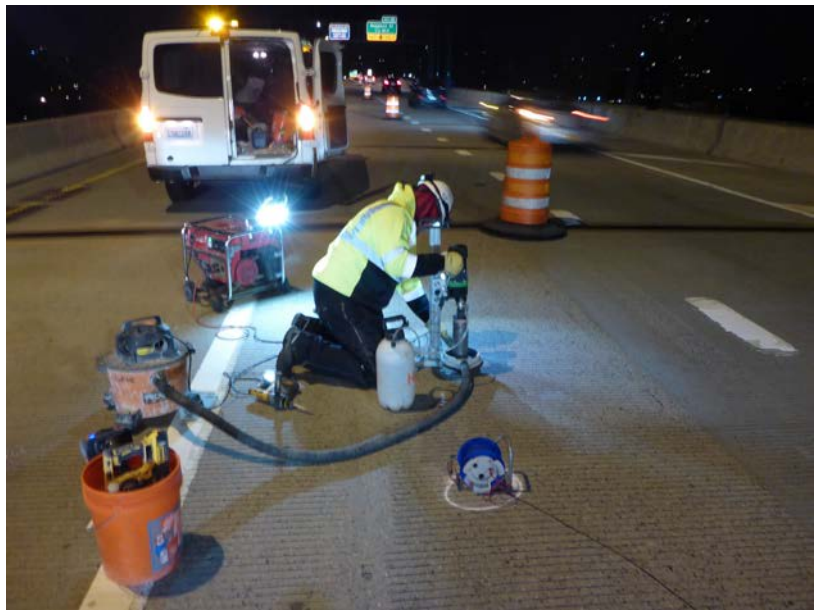
Existing Structures

- **“Modern” In-service Bridges:** Appropriately timed investigations to prescribe preservation vs. repair measures.
- **“Vintage” In-service Bridges:** Understanding of previous repairs, changes in exposure, and associated performance to cost-effectively determine rehabilitation vs. replacement.

Inspection Considerations

- Temporary Lane Closures

- Weather



- Rush-Hour Restrictions

National Bridge Inspection Standards (NBIS) Framework

- Visual Inspection and Conventional Sounding
- “Condition State” Documentation
- *Wearing Surface, Superstructure, Substructure*

Typical NBIS Inspection Report

	Quantity		Condition State Quantities			
Description	**Total**	**Unit**	**CS 1**	**CS 2**	**CS 3**	**CS 4**
RC-DECK	9,666	SF	9,183	483		
Updates from Field Inspection:						

[ITEM 58] DECK:	6-SATISFACTORY CONDITION
RATING :	05/18/2001
[ITEM 59] SUPER:	6-SATISFACTORY CONDITION
RATING :	06/01/2017
[ITEM 60] SUB:	5-FAIR CONDITION
RATING :	01/22/2015

DECK PROTECTIVE COMPONENTS:

SERIES TYPE-#	***COMPONENT***	***MATERIAL***	***CONSTRUCTION***
APPROACH SERIES-1	*WEARING SURFACE*	*PLAIN CONCRETE*	*MONOLITHIC*

COMMENT:

CONDITION	***LOCATION 1***	***LOCATION 2***
DECK PROTECTION	*EPOXY POLYMER*	*COATED REBAR*

Repair Methodology

- **Maintenance**
  - Surface and Crack Sealers
  - Local Concrete Patching
- **Rehabilitation**
  - Overlays (Concrete or Asphalt)
  - Cathodic Protection
- **Deck Replacement**
- *Other Considerations*

DOT Guidance

IDOT – BCR Procedures & Practices

Deck Repair vs. Replacement Assessment Table		
Equal Width Decks[(1)]:	Decks Requiring Widening[(1,2)]:	Recommendation:
≤ 25%	≤ 15%	Deck repair cost effective[(3)]
26-35%	16-25%	Deck repair cost effective only in well documented cases[(4)]
> 35%	> 25%	Deck replacement appropriate

Notes to Table:

(1) – Deck area calculated using length x face-face parapet width.
(2) – This column pertains to deck widening which requires additional beam/s only.
(3) – For decks containing sidewalks and raised medians with significant amounts of repair/replacement work required, separate cost analysis estimates should be completed to justify deck repair versus deck replacement.
(4) – In this case deck repair may be considered appropriate when a detailed cost analysis and/or well documented exterior constraints indicate deck repair is more advantageous.

DOT Guidance

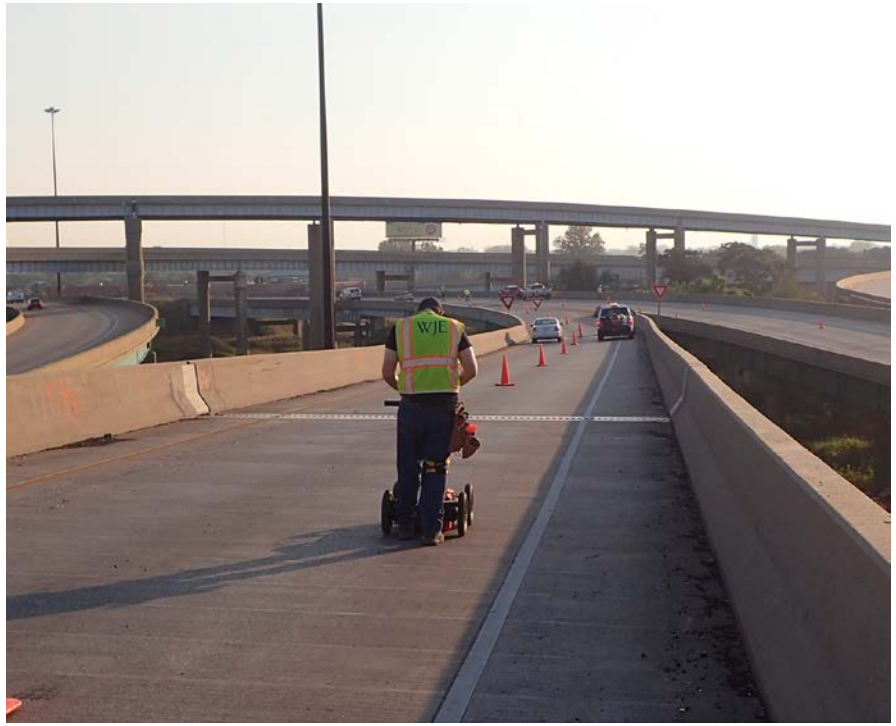
NyDOT – Bridge Deck Evaluation Manual

The total removal area is based solely on technical considerations and represents that necessary to assure that at least half of the repaired deck achieve the service lives given in Chapter III. At some locations, conditions may exist requiring greater confidence in longevity of the rehabilitation. Specifically, 100% deep concrete removal may be justified on bridges in urban areas with high-traffic density whenever one or more of the following conditions are met:

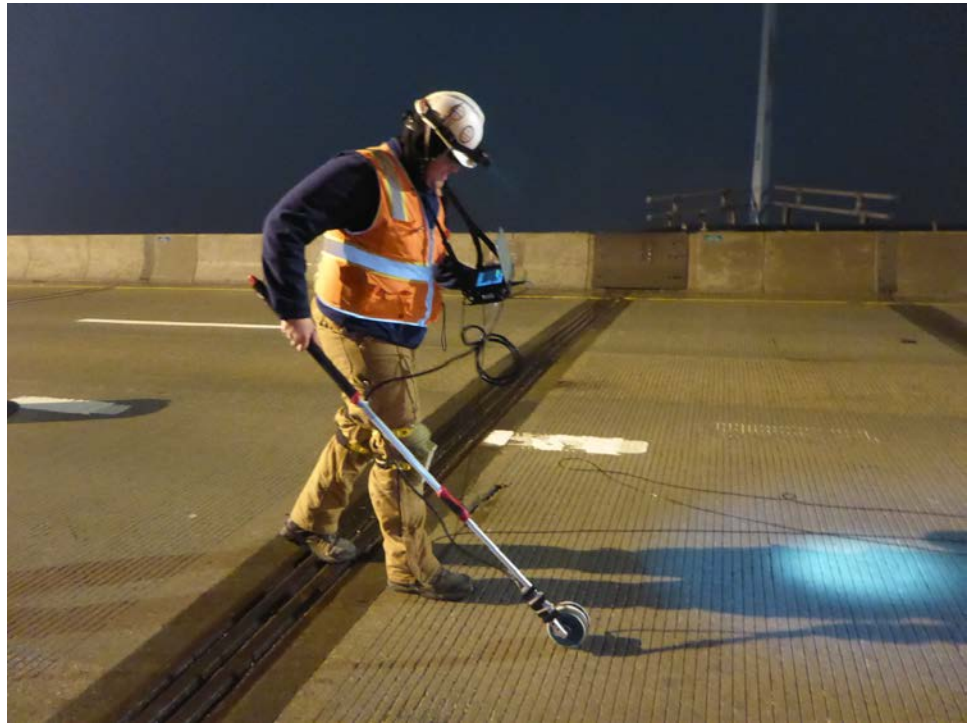
1. Area of spalls exceeds 2%,
2. Area of delamination exceeds 30%,
3. Area of half-cell potential greater than 0.35 exceeds 40%, or
4. Total damaged area exceeds 50%.

These conditions are exclusive of distress within 2 ft. of a bridge joint.

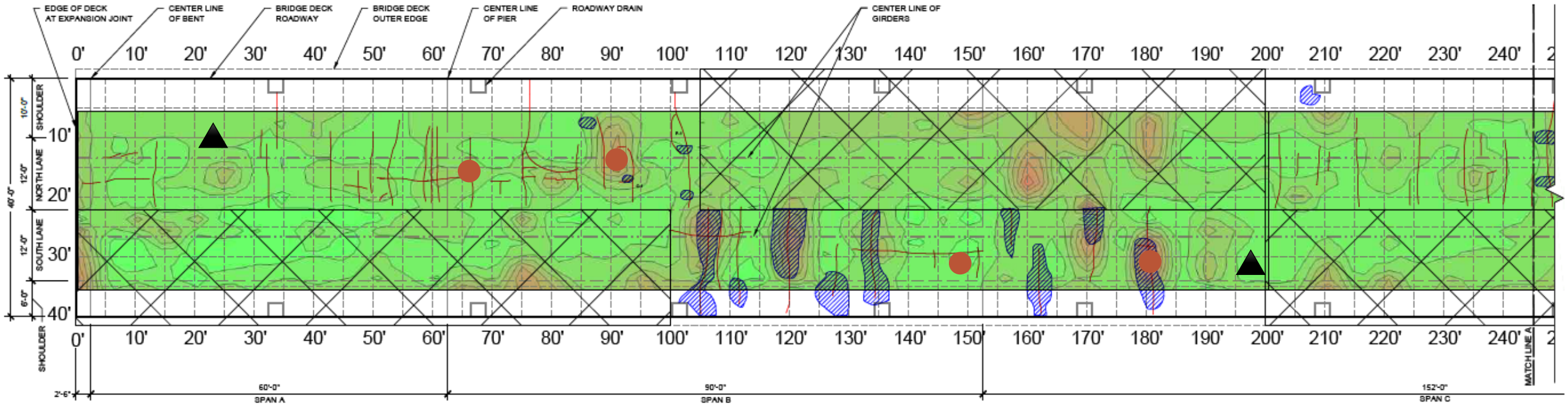
Nondestructive Evaluation (NDE)



- Ground Penetrating Radar
- Corrosion Assessment
- Infrared Thermography
- Emerging Technologies (Automated Scanning Systems and AI Damage Detection)



Deterioration and Risk Maps



LEGEND

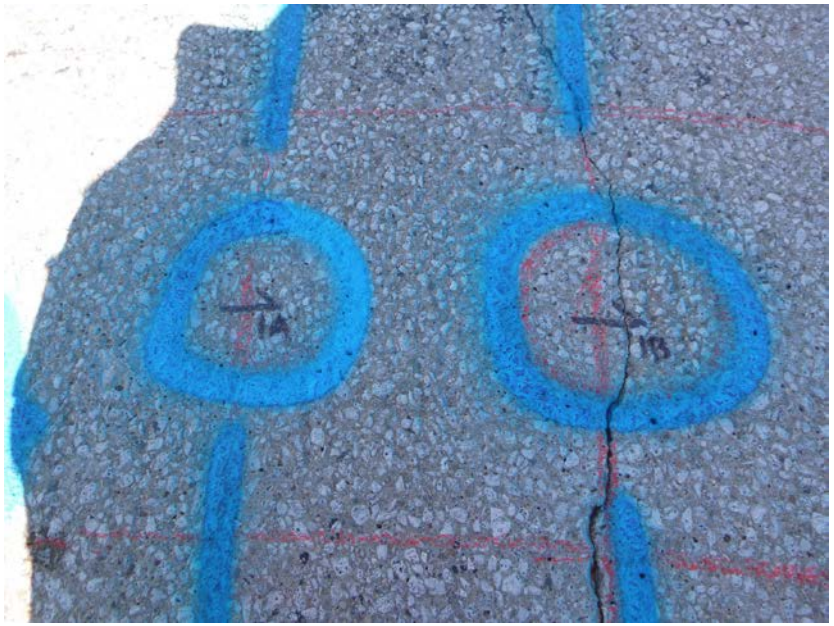
- CORE LOCATION
- PULL-OFF TEST LOCATION
- CONCRETE CRACK
- CONCRETE DELAMINATION
- CONCRETE REPAIR AREA
- VISUAL SURVEY NOT PERFORMED

POTENTIAL CONTOUR SCALE
(mV REF. CSE)

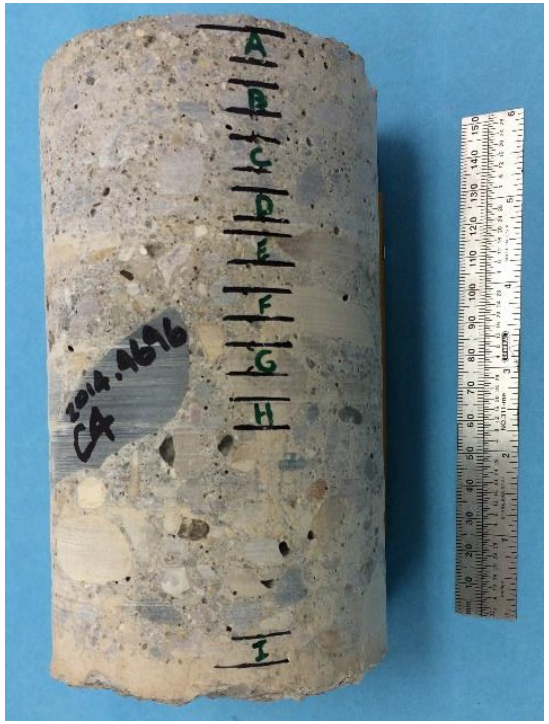
0 50 100 150 200 250 300 350 400 450 500 550

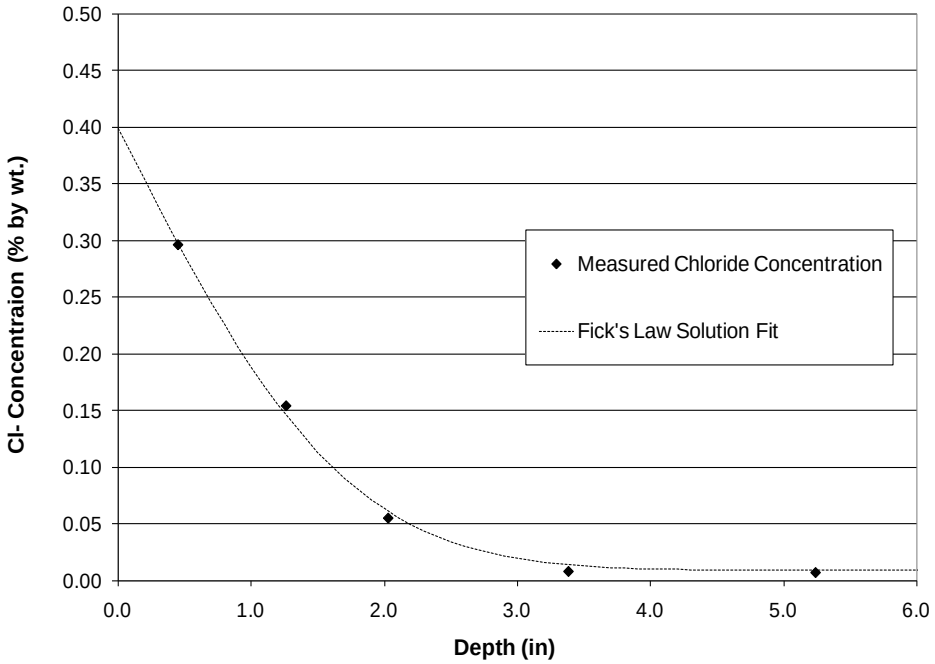
Material Sampling

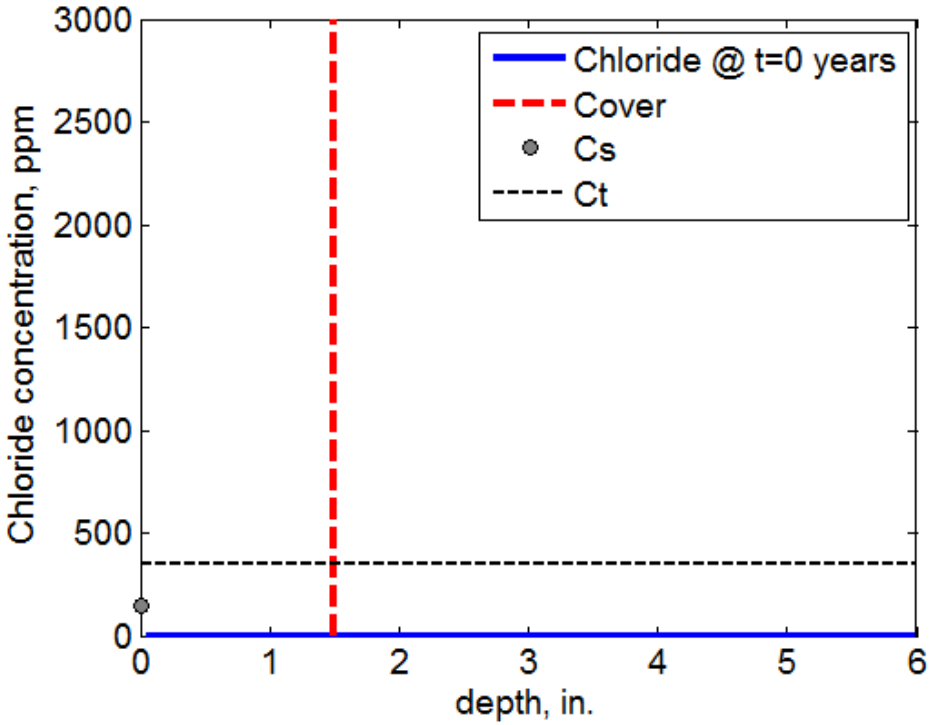
- Core Samples
- Inspection Openings
- Chloride Testing
- Petrographic Examination



Chloride Concentration Evaluation

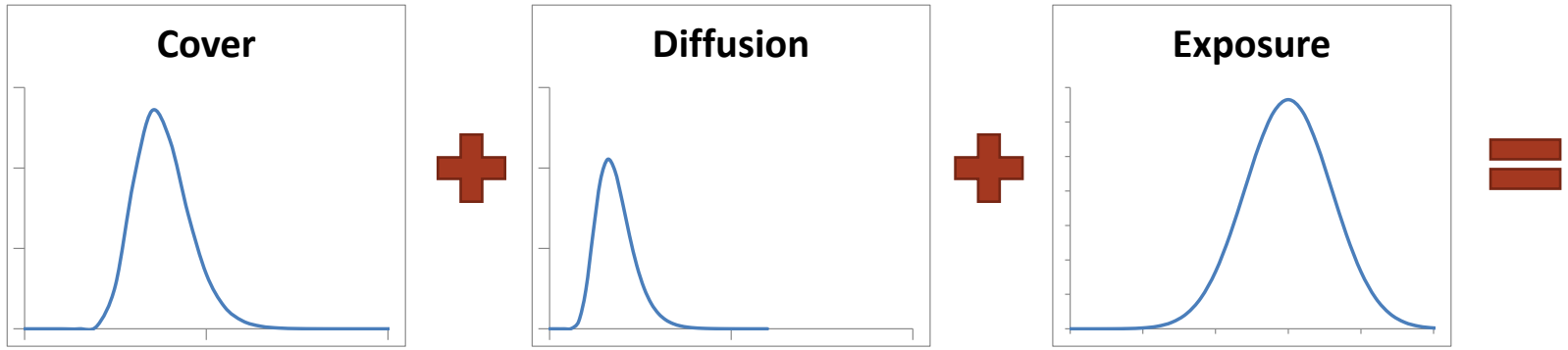


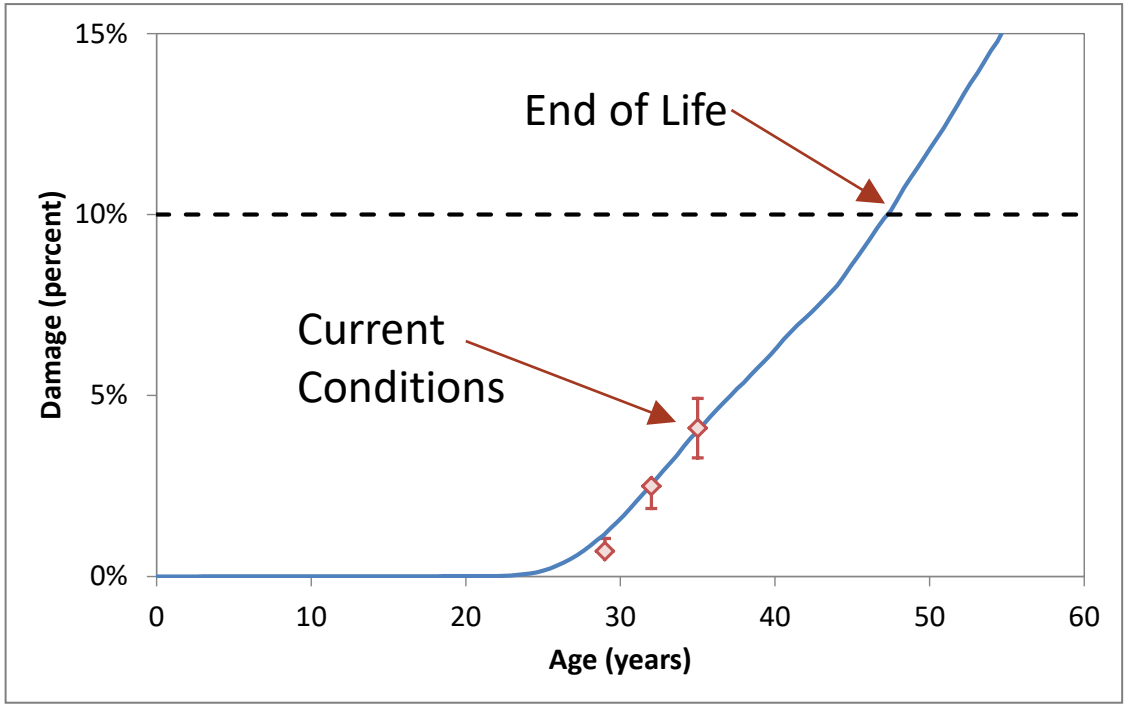




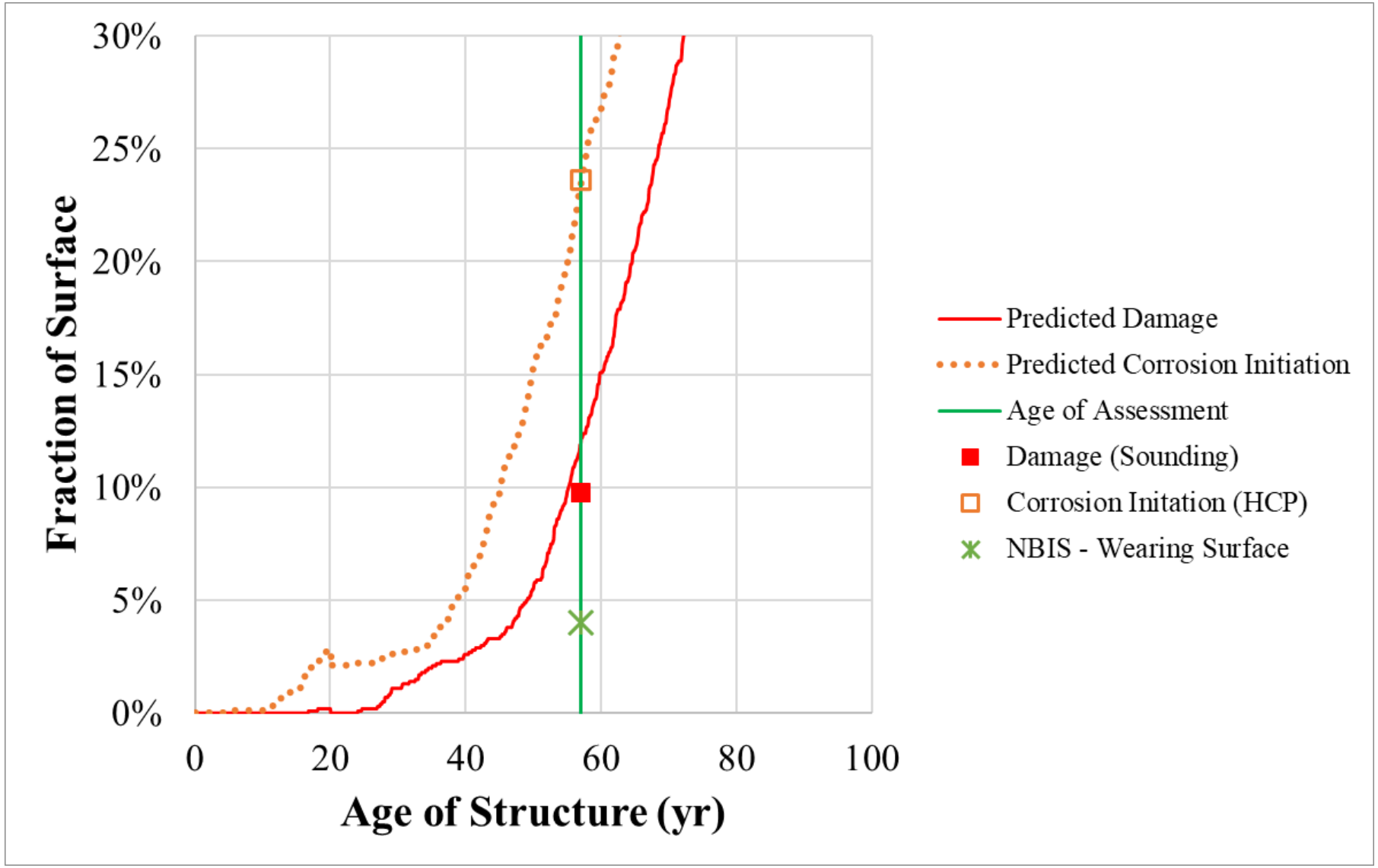
- Slices for Water- and/or Acid-Soluble Chloride Testing
- Chloride Concentration and Diffusion Profile
- Chloride Ingress and Corrosion Initiation Modeling

Basics of Service Life Modeling

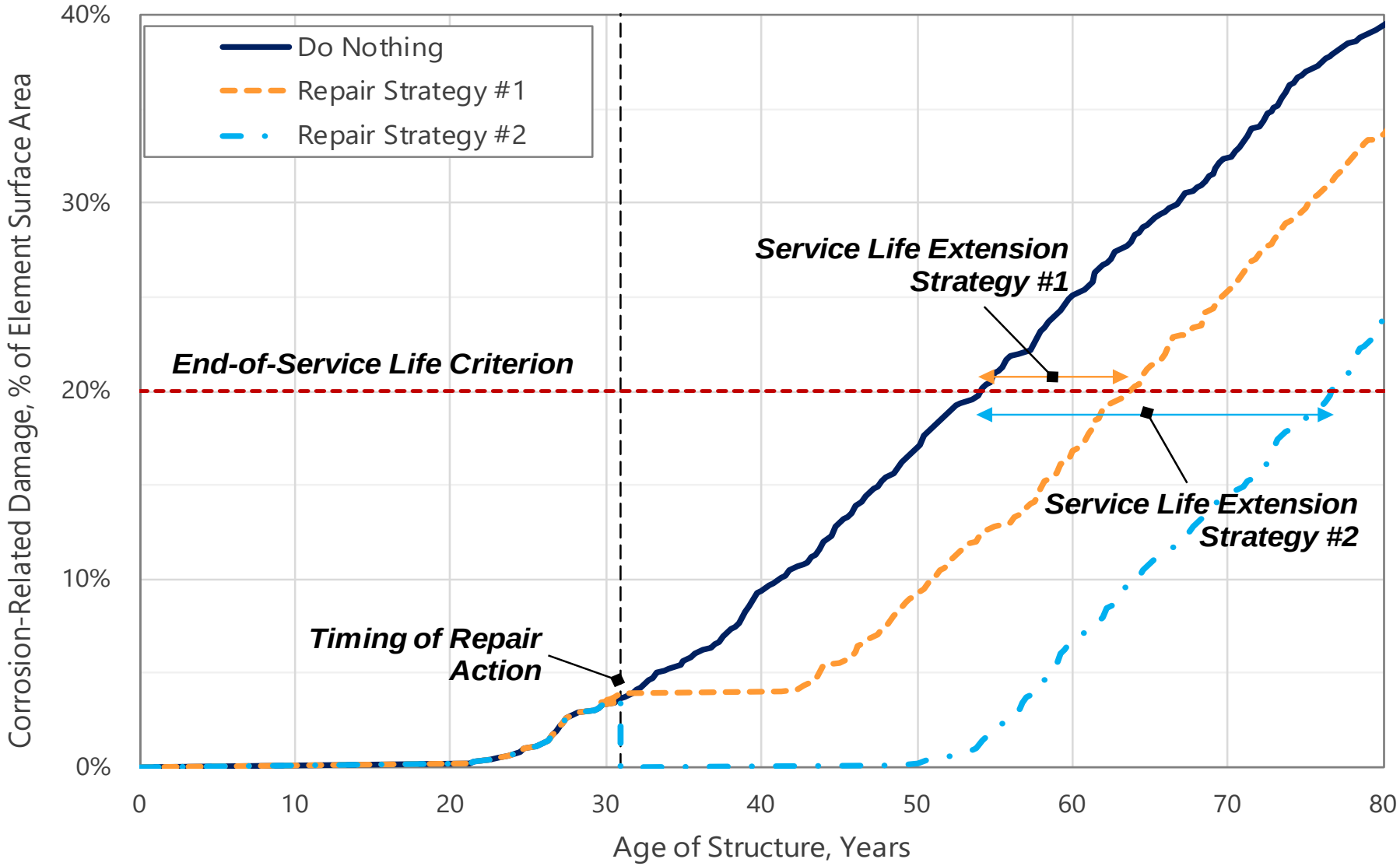




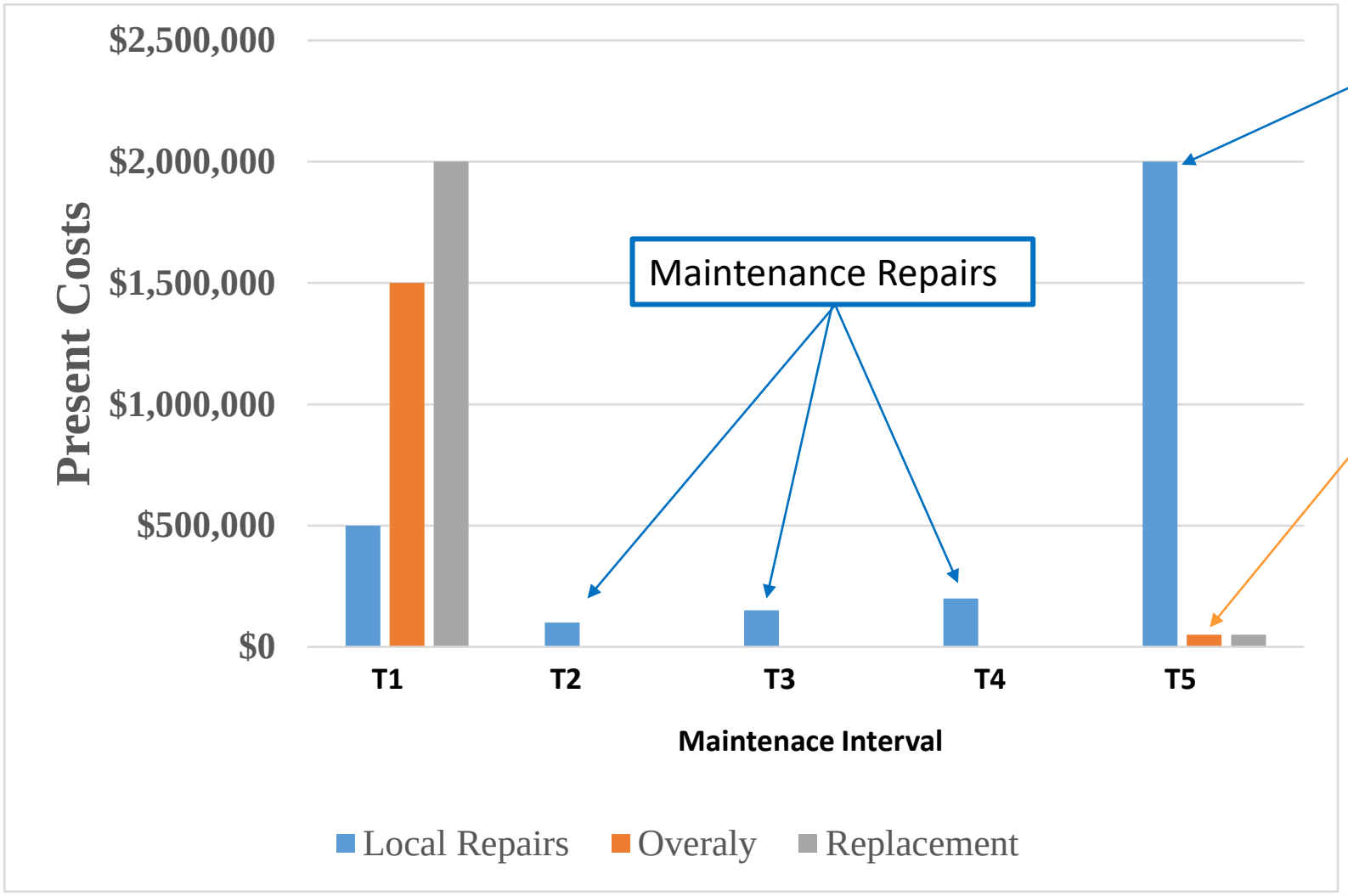
Data Fusion


30%
25%
20%
15%
10%
5%
0%
Fraction of Surface
0
20
40
60
80
100
Age of Structure (yr)
Predicted Damage
Predicted Corrosion Initiation
Age of Assessment
Damage (Sounding)
Corrosion Initation (HCP)
NBIS - Wearing Surface

Service Life Extension



Life Cycle Cost Analysis (LCCA)

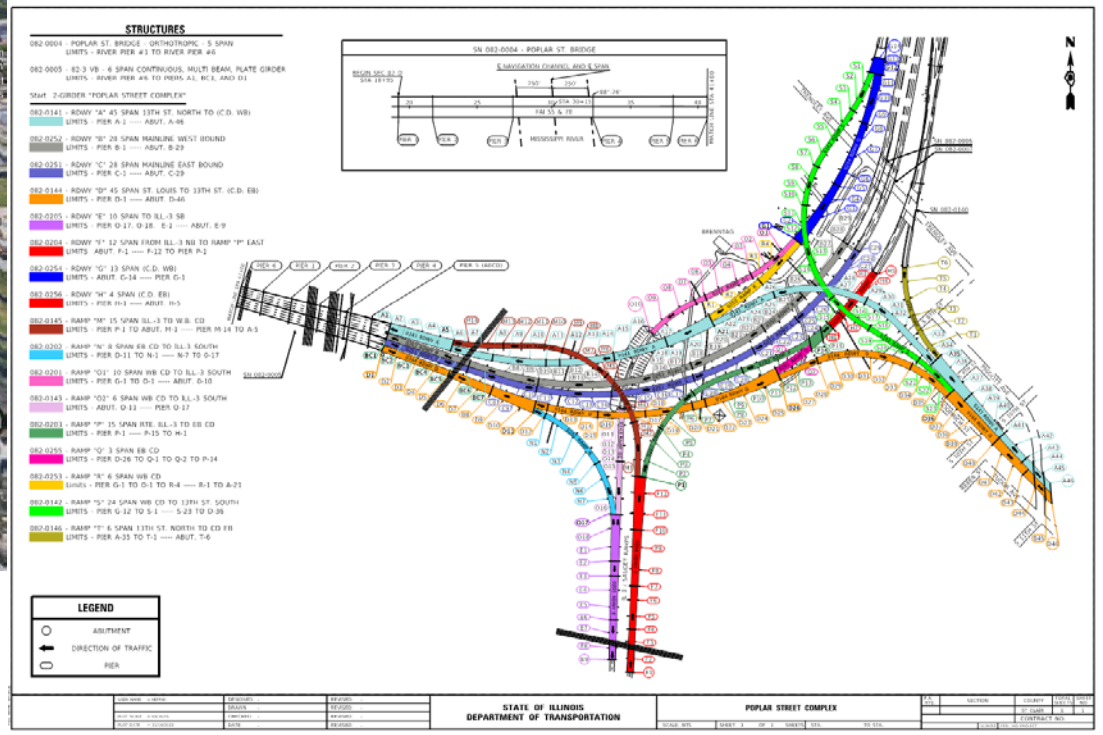


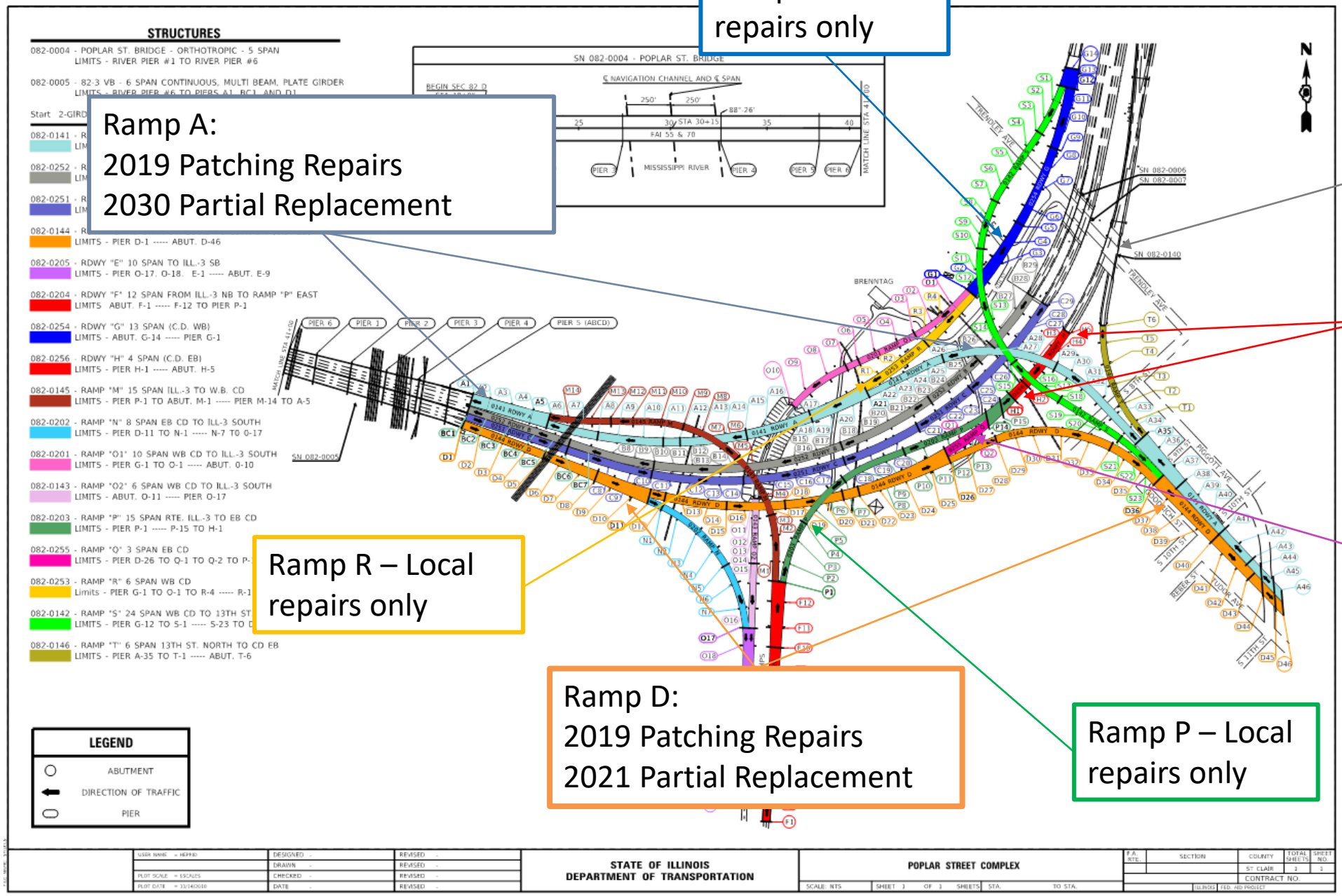
Deferred Replacement

Maintenance Repairs

Maintenance Repairs

Asset Management





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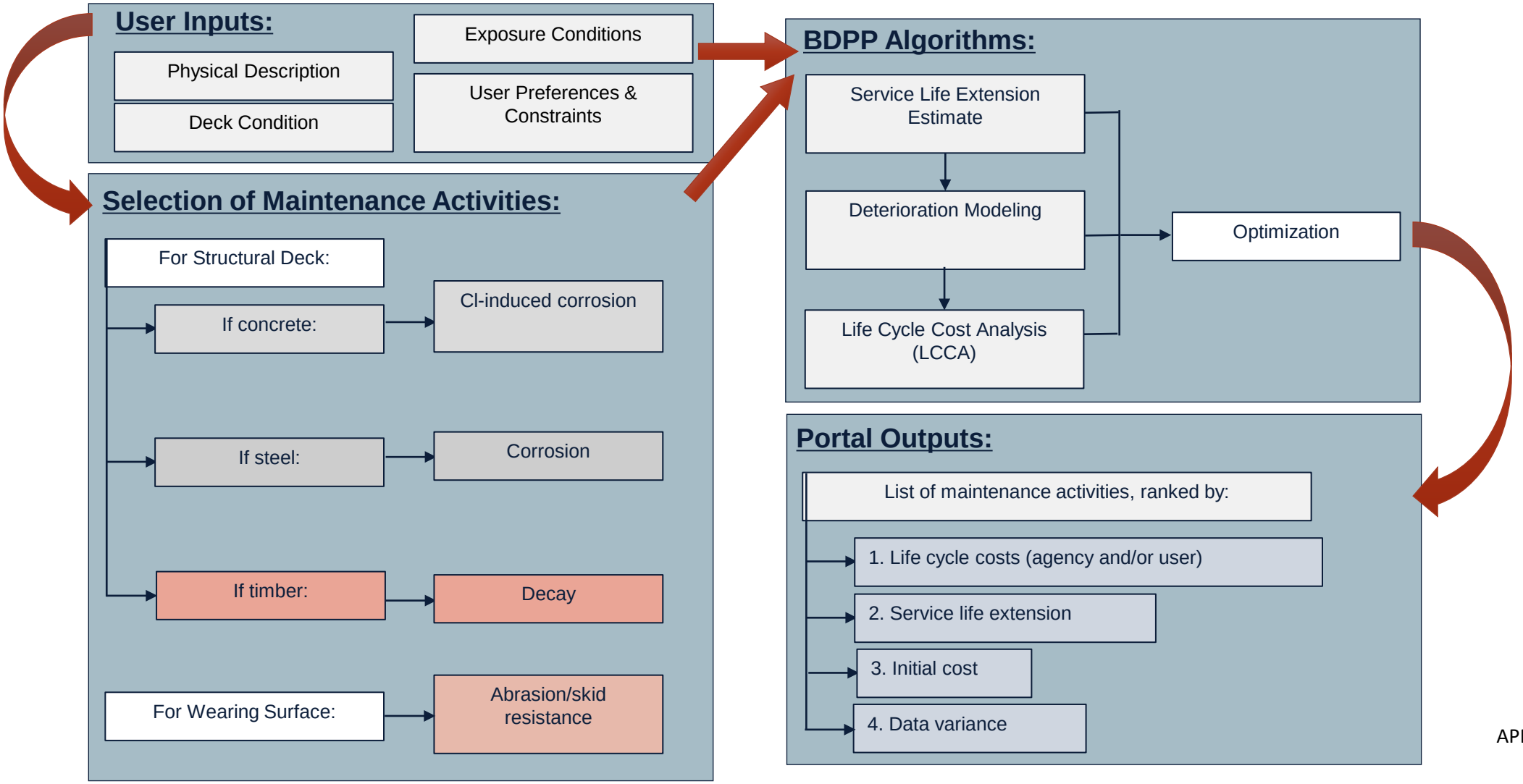
LTBP “InfoBridge”

Bridge Deck Preservation Tool (BDPT)



Recent Trends in Bridge Rehabilitation

- Structure Widening and Barrier Retrofit
- Polyester Polymer Concrete Overlay
- Joint Removal and Link Slab Installation
- Holistic Considerations for Structure Rehabilitation

Toll Road Bridge

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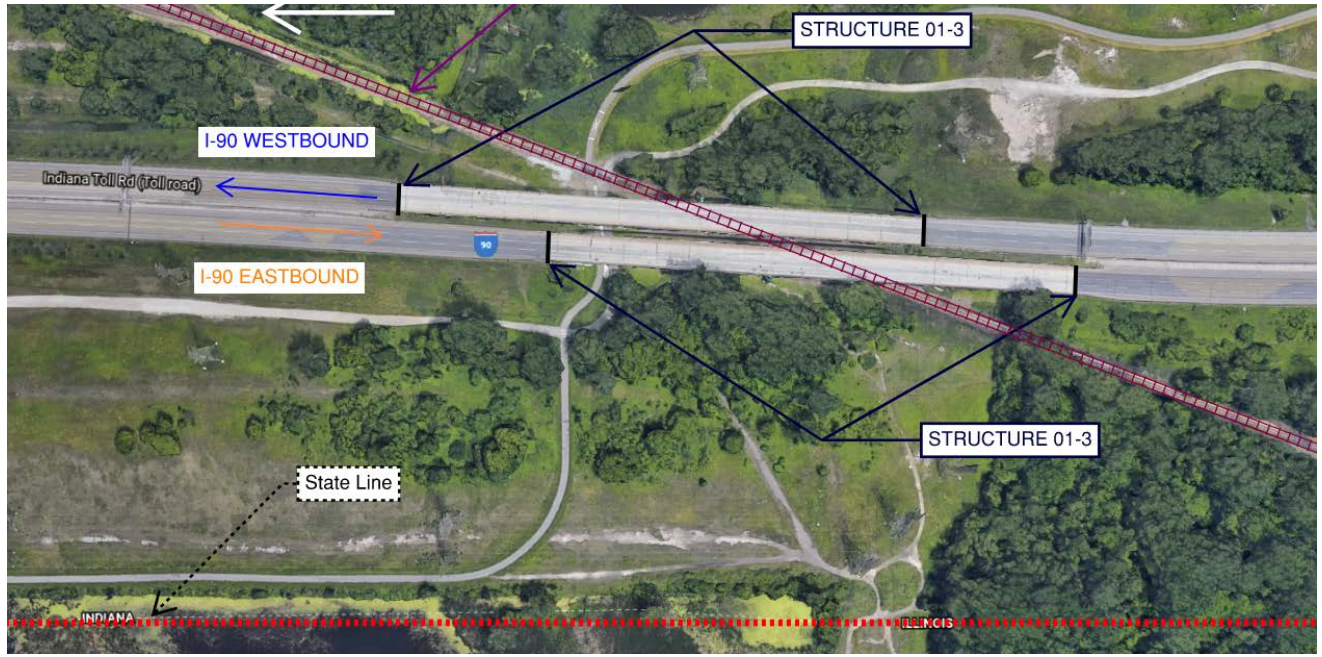
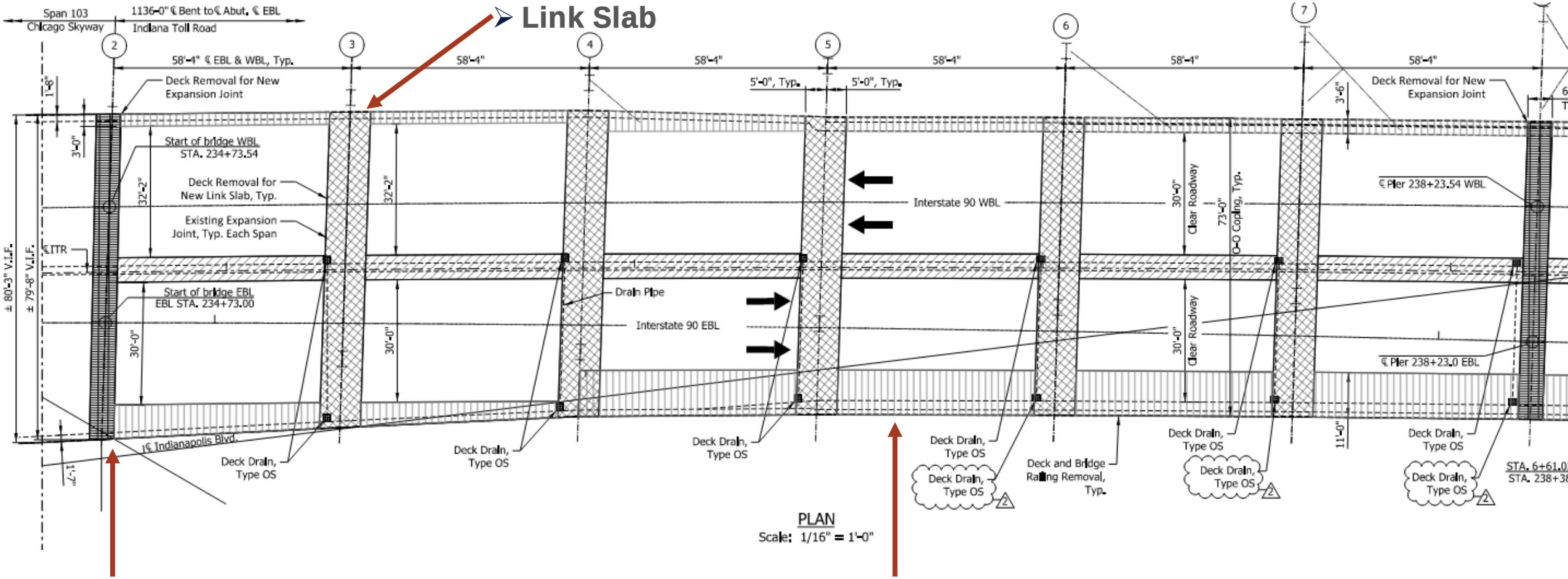
NORTH
INDIANA
ILLINOIS
STATE LINE
STRUCTURE 01A-1
INDIANAPOLIS AVENUE
I-90 WESTBOUND
I-90 EASTBOUND
Norfolk Southern
Colehour Yard
STRUCTURE 01A-3
108TH STREET
Indianapolis
S Indianapolis Ave
Indiana Welcome Sign
Indiana Toll Rd (Toll road)
CITGO
Dunkin'
Mike's Tint Shop
ALDI
KFC
McDonald's
Southeast Area
Elementary School
Blue Kangaroo
Coin Laundry
Burger King
Birrieria Ocotlan
East Side
STRUCTURE 01A-3-1
108TH STREET
N.I.C.


STRUCTURE 01-3
I-90 WESTBOUND
Indiana Toll Rd (Toll road)
I-90 EASTBOUND
STRUCTURE 01-3
State Line
INDIANA
ILLINOIS

Toll Road Bridge

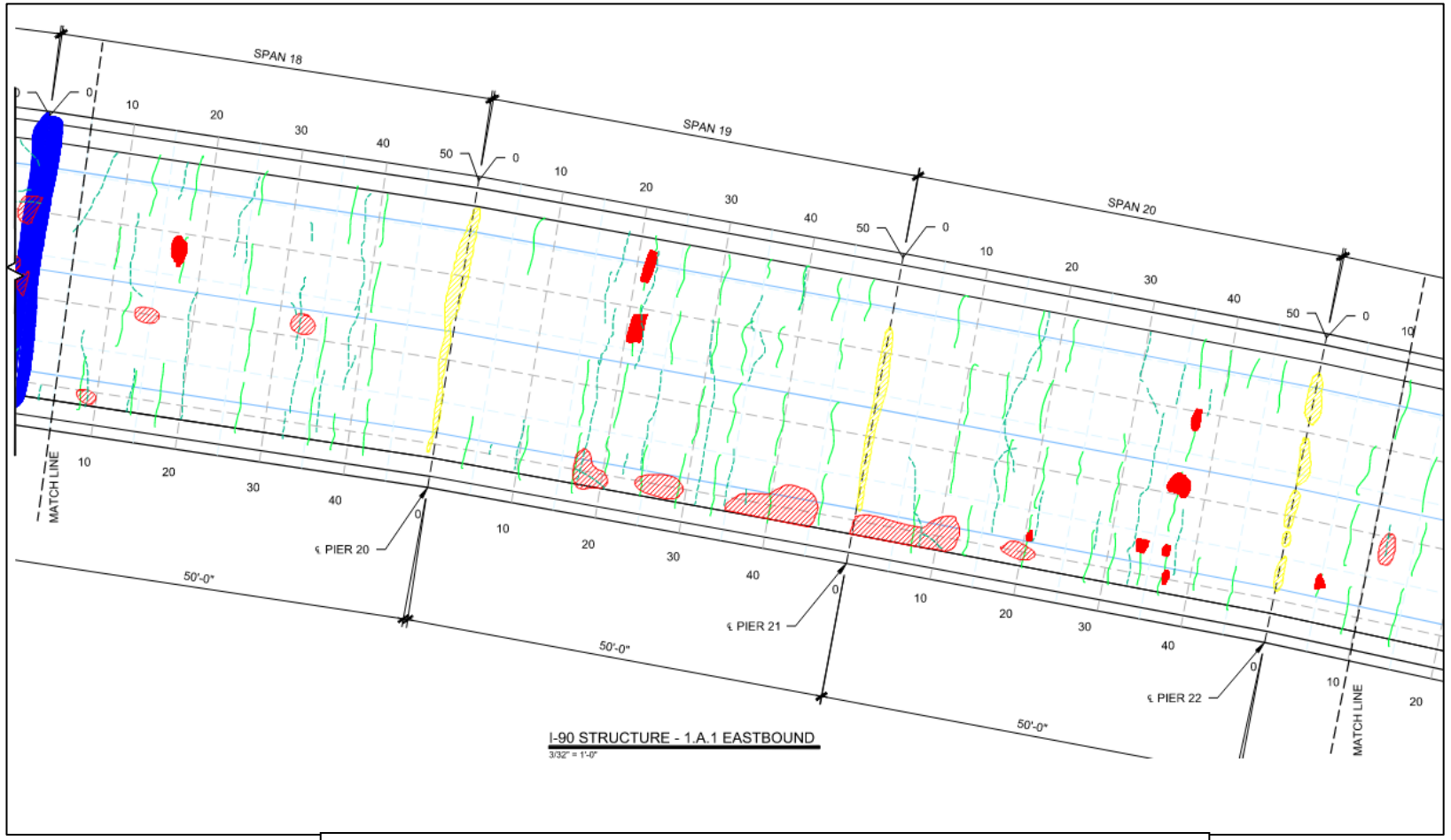


➢ Link Slab

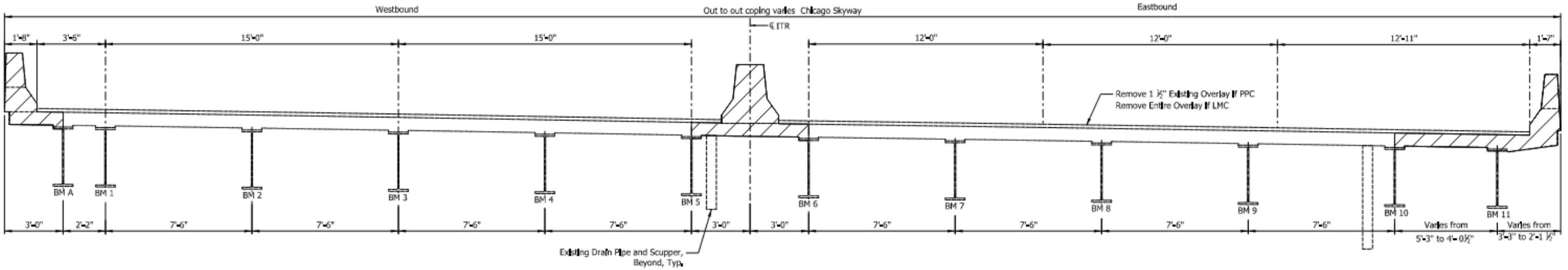
➢ Strip Seal Expansion Joint

➢ Widening

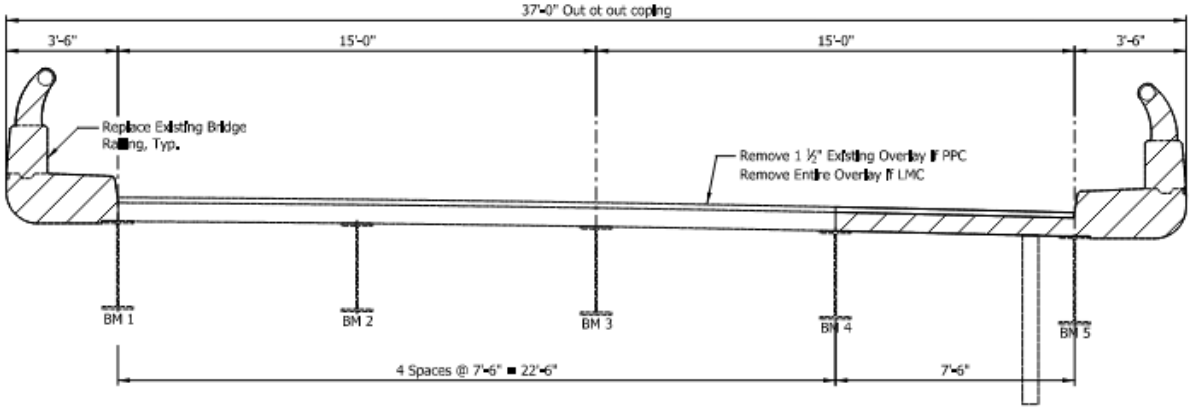
Toll Road Bridge



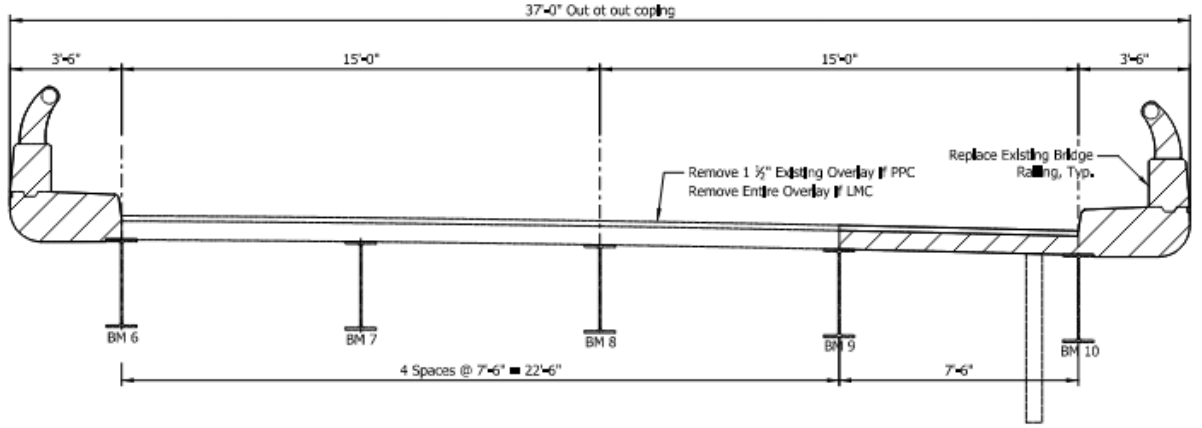
Toll Road Bridge



CROSS SECTION AT SPAN 1
(LOOKING SOUTH)

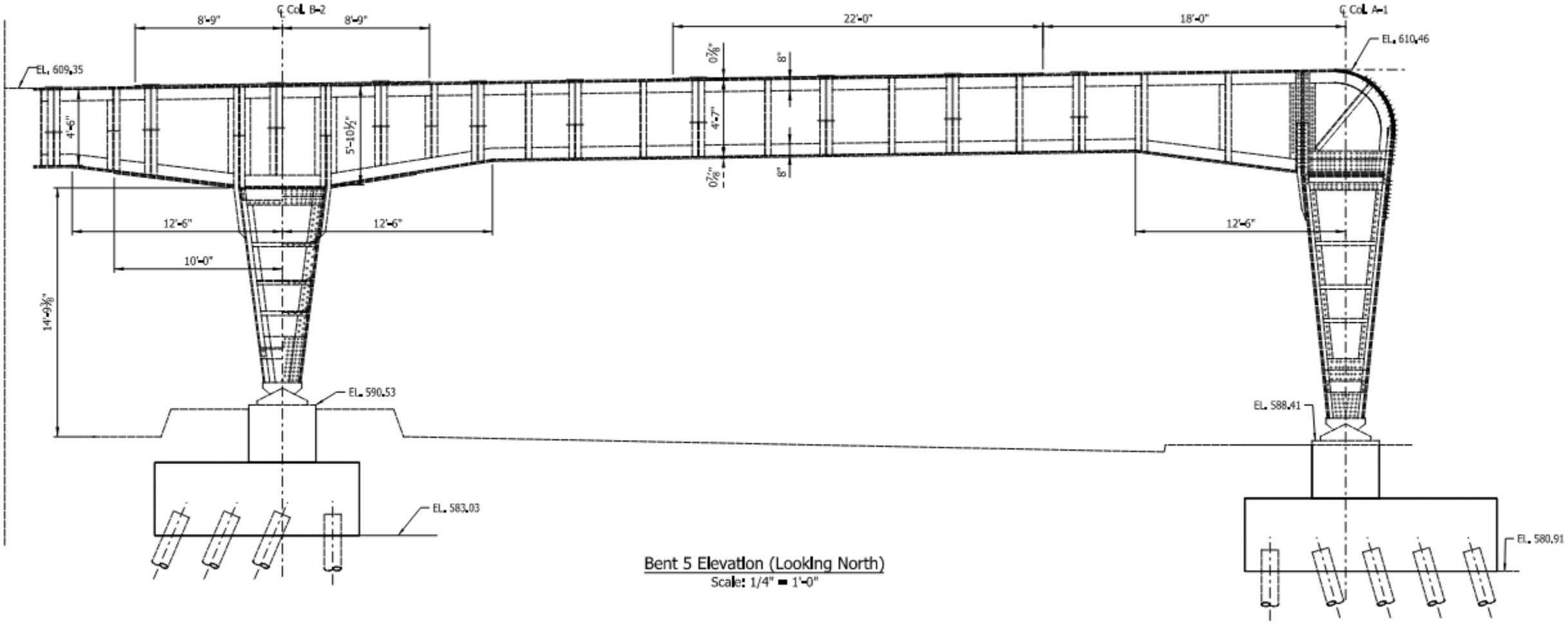


WESTBOUND CROSS SECTION WITHOUT MEDIAN AT SPANS 13- 21
(LOOKING SOUTH)



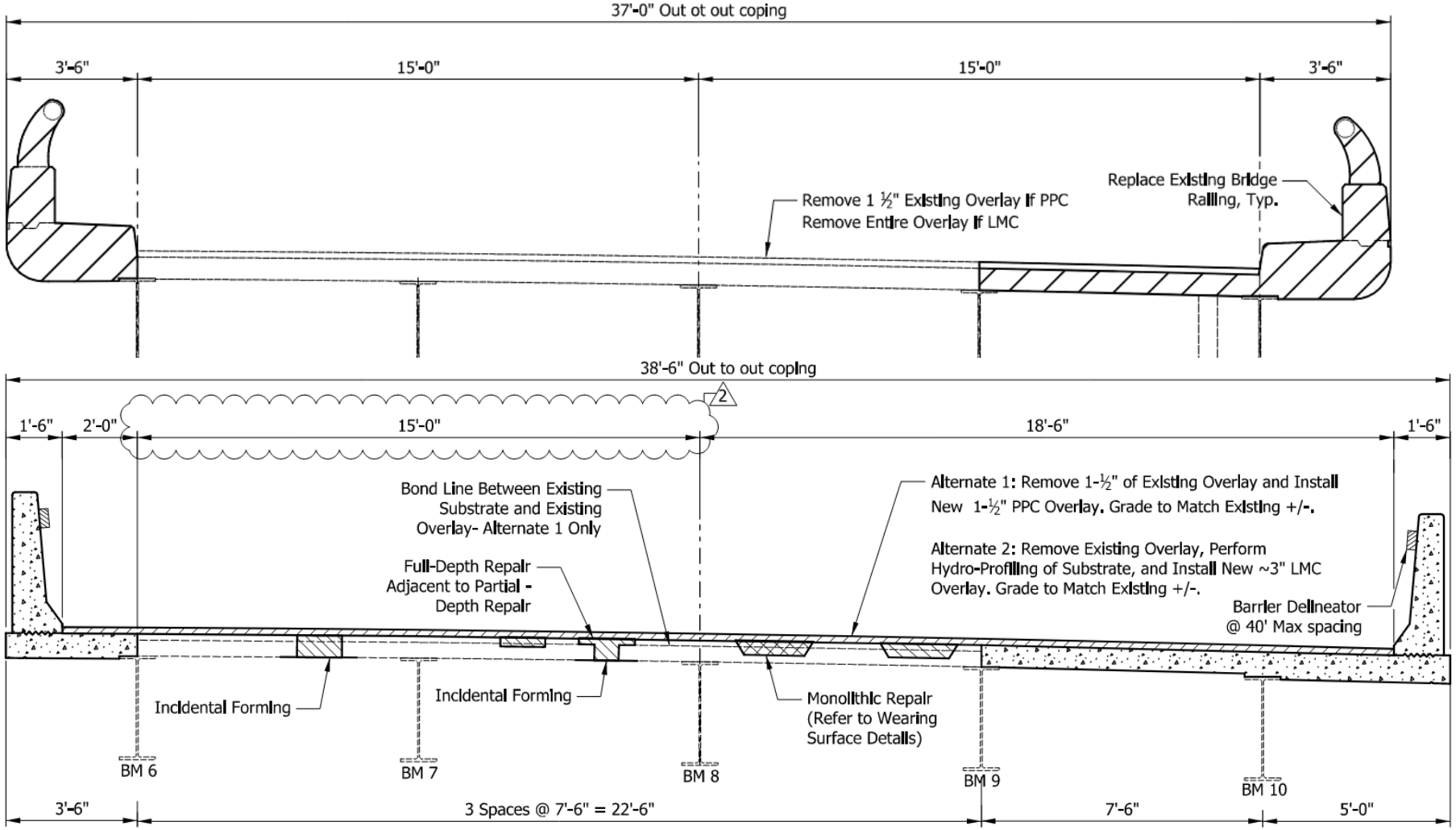
EASTBOUND CROSS SECTION WITHOUT MEDIAN AT SPANS 13- 21
(LOOKING SOUTH)

Toll Road Bridge



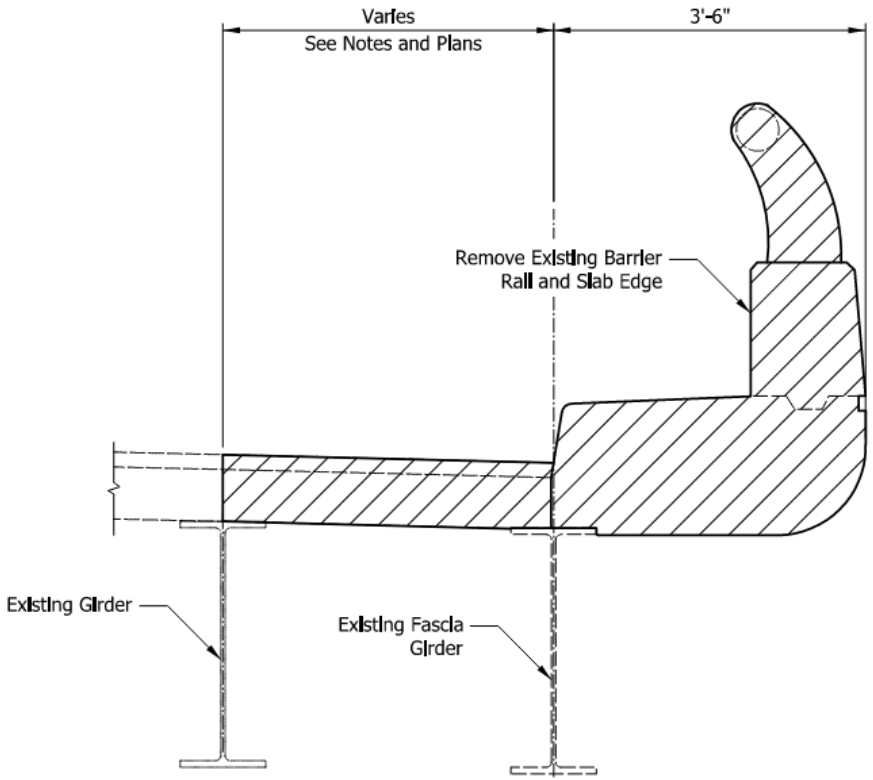
Bent 5 Elevation (Looking North)
Scale: 1/4" = 1'-0"

Structure Widening and Barrier Retrofits



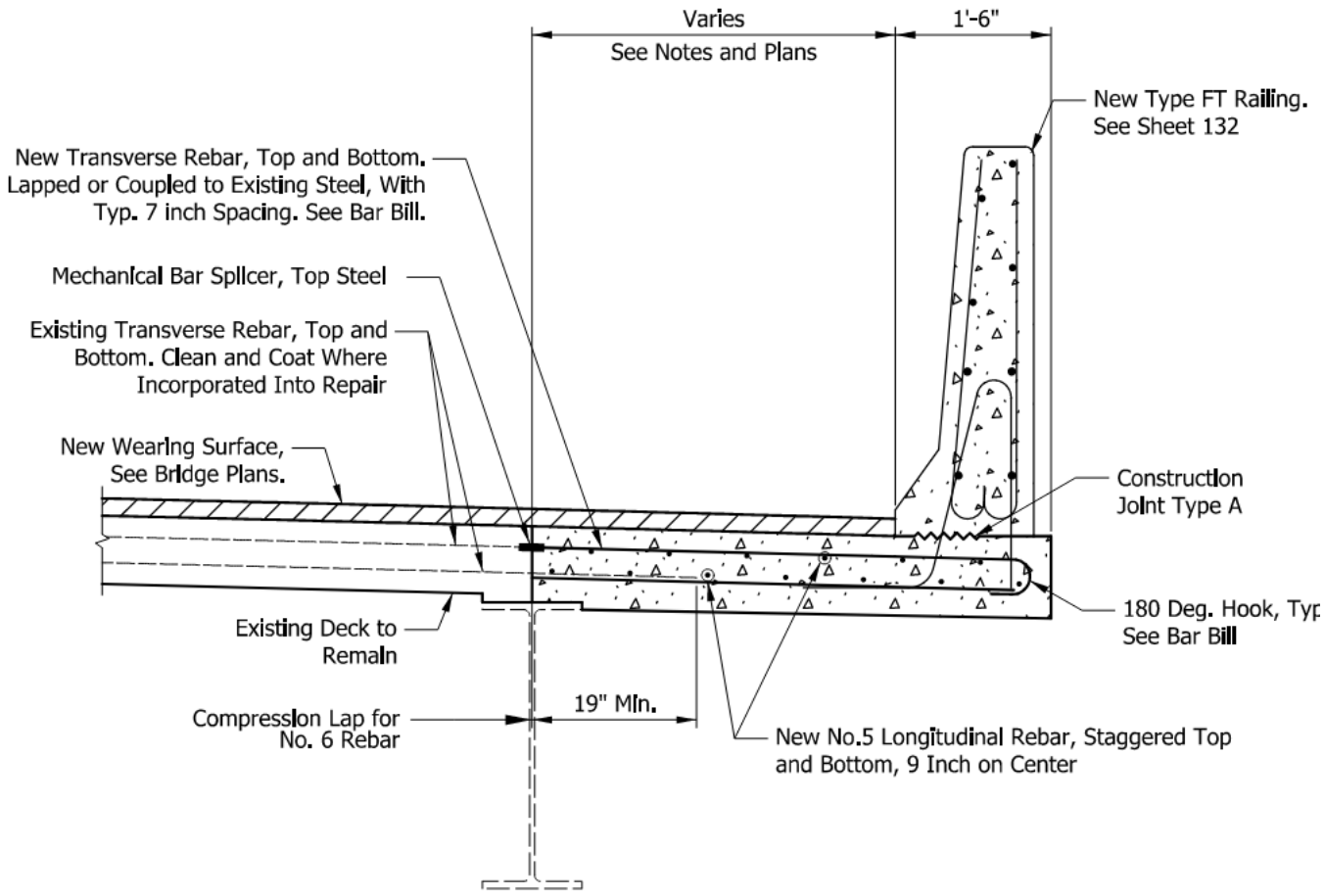
- Existing
- Proposed

Structure Widening and Barrier Retrofits

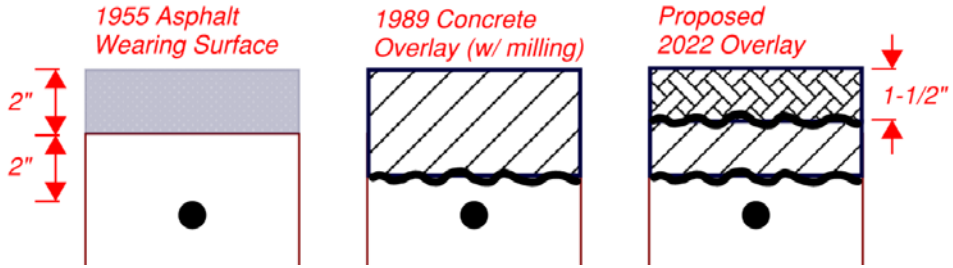


DETAIL 1A.1 - REMOVAL OF ORIGINAL BARRIER
Scale: 3/4" = 1'-0"

Structure Widening and Barrier Retrofits

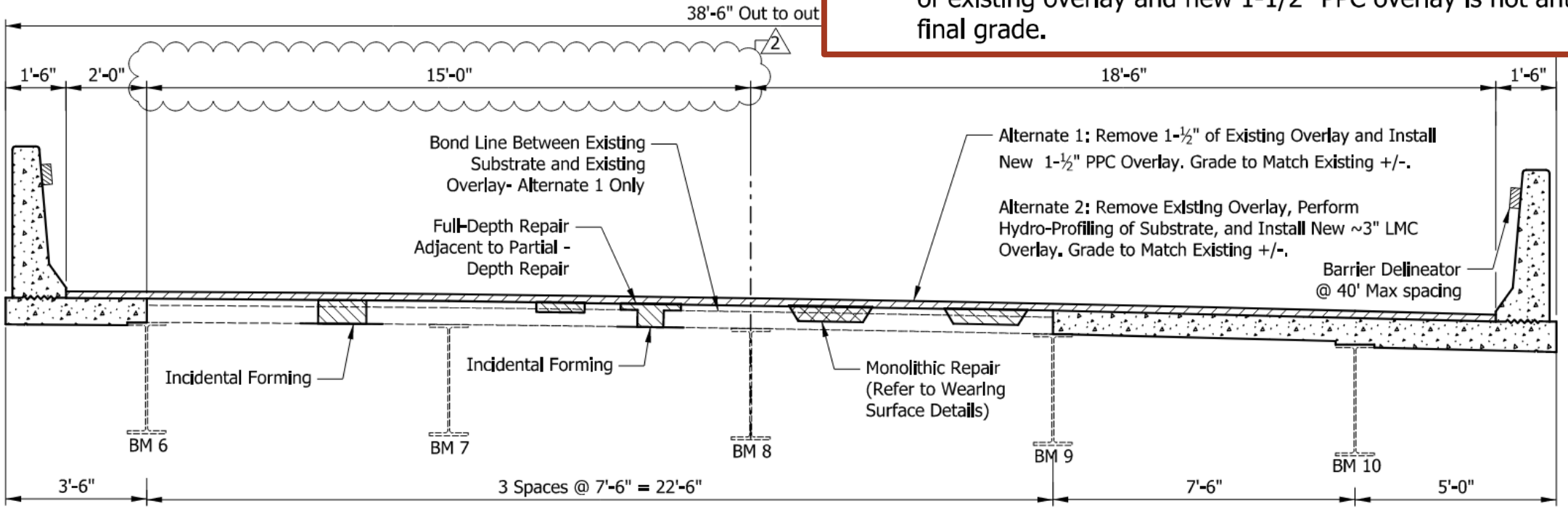


Polyester Polymer Concrete Overlay



Existing Conditions and Final Grade

1. Based on 2020 field measurements and core samples, existing dimensions for Structure 01A.1 are as follow. Average cover depth to top layer of reinforcement is 4.9 inches, varying from 3.2 to 6.9 inches. Average overlay thickness is 3.1 inches, varying from 2.1 to 4.7 inches (excluding previous partial-depth repairs). Calculated total deck thickness, including overlay and based on repair history, is approximately 9 inches. Anticipated partial-removal of existing overlay and new 1-1/2" PPC overlay is not anticipated to change final grade.



Overlay Bond Testing

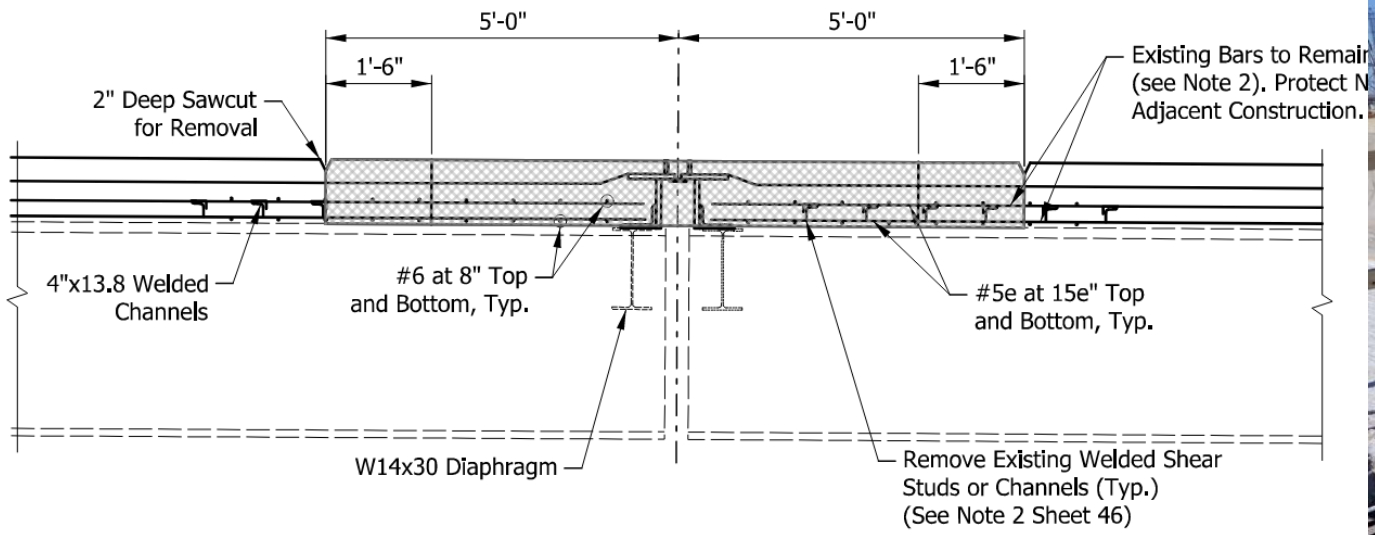
- Milling to final grade

- Bond-testing of existing overlay to remain

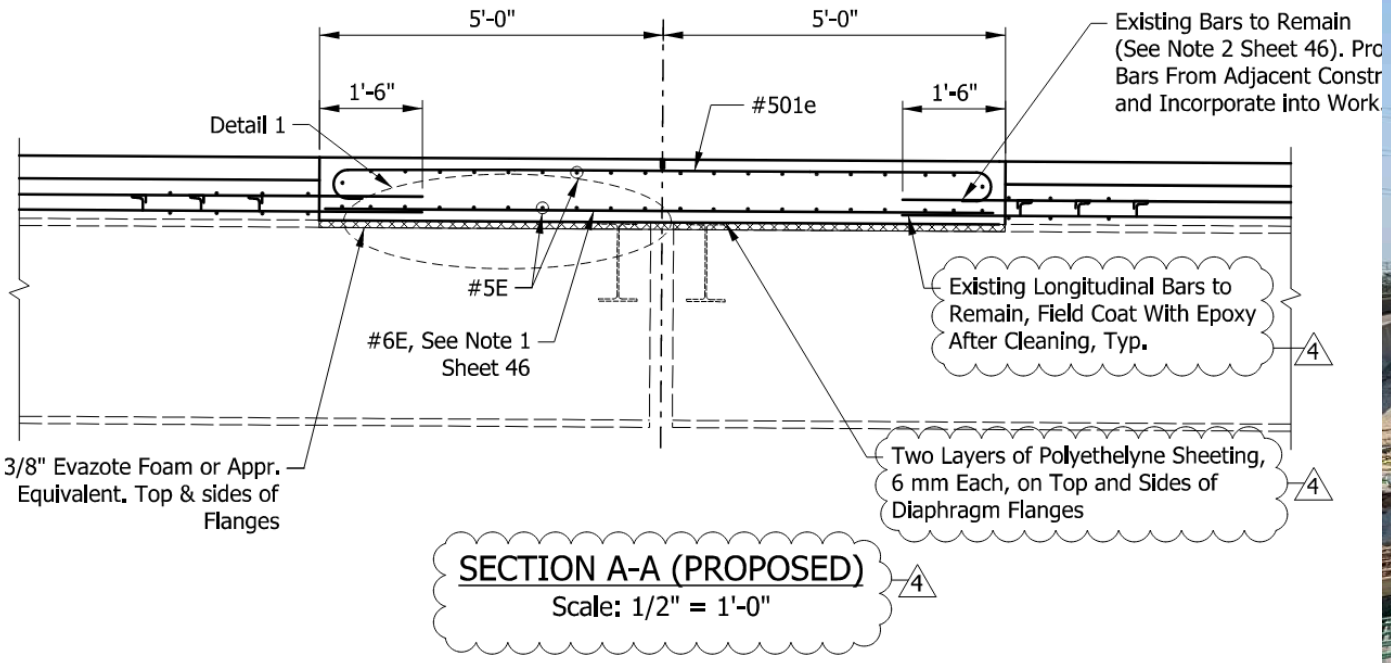
Polyester Polymer Concrete Overlay

Polyester Polymer Concrete Overlay

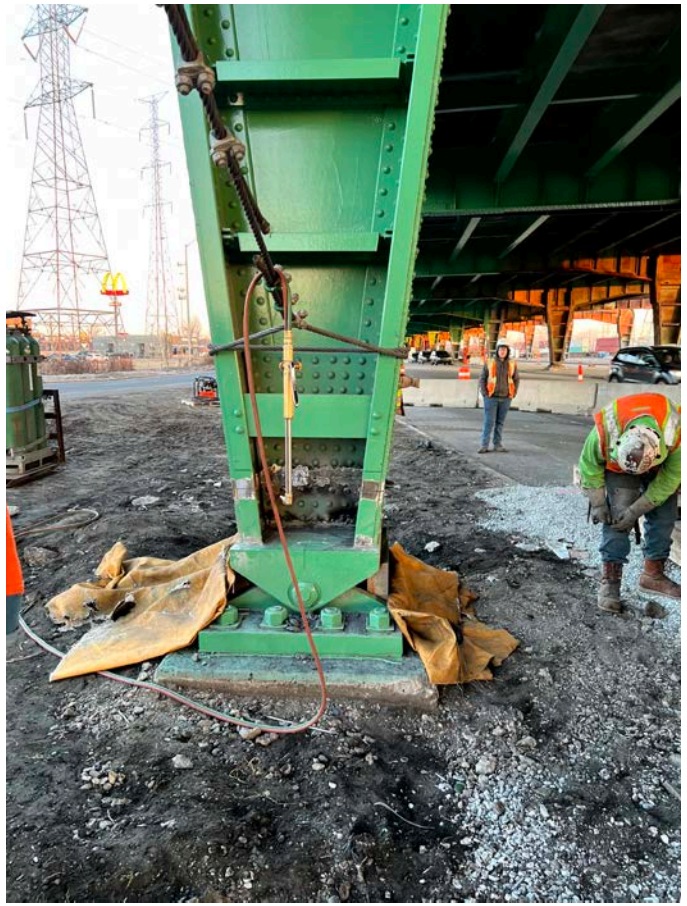
Joint Removal and “Link Slab” Installation

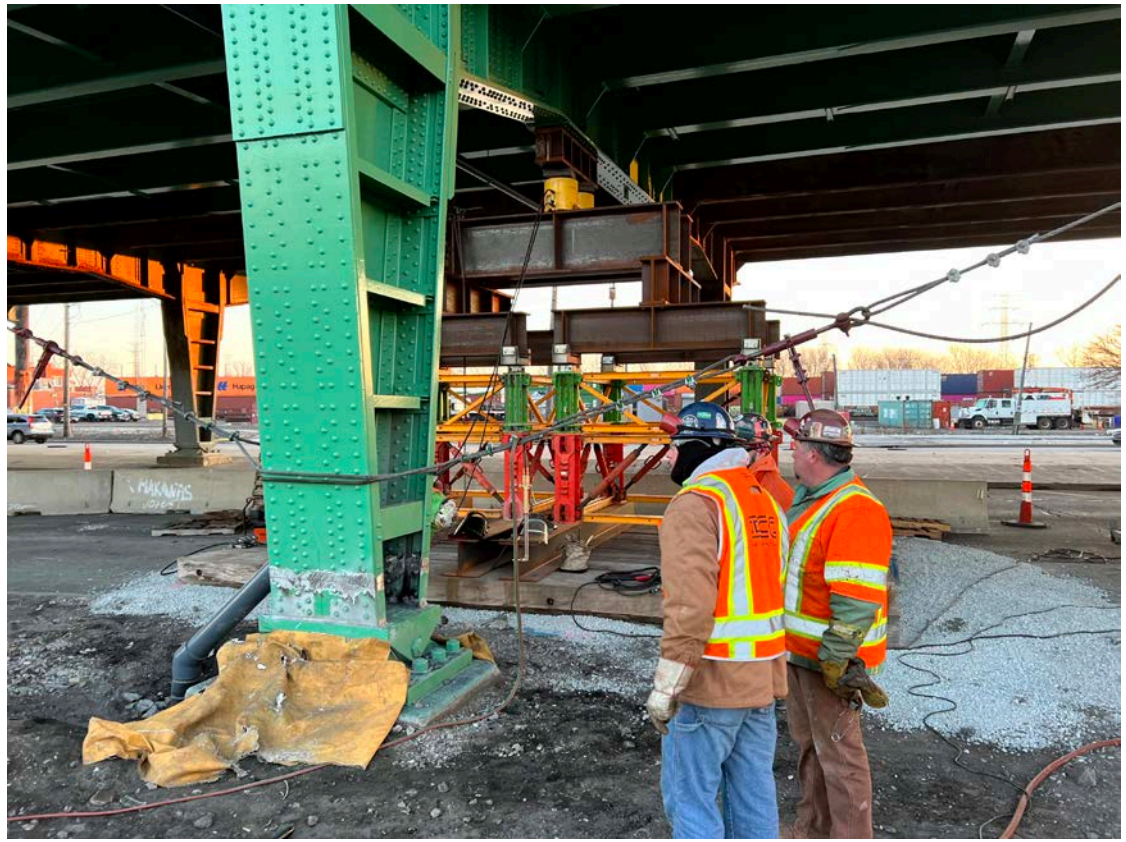


Joint Removal and “Link Slab” Installation



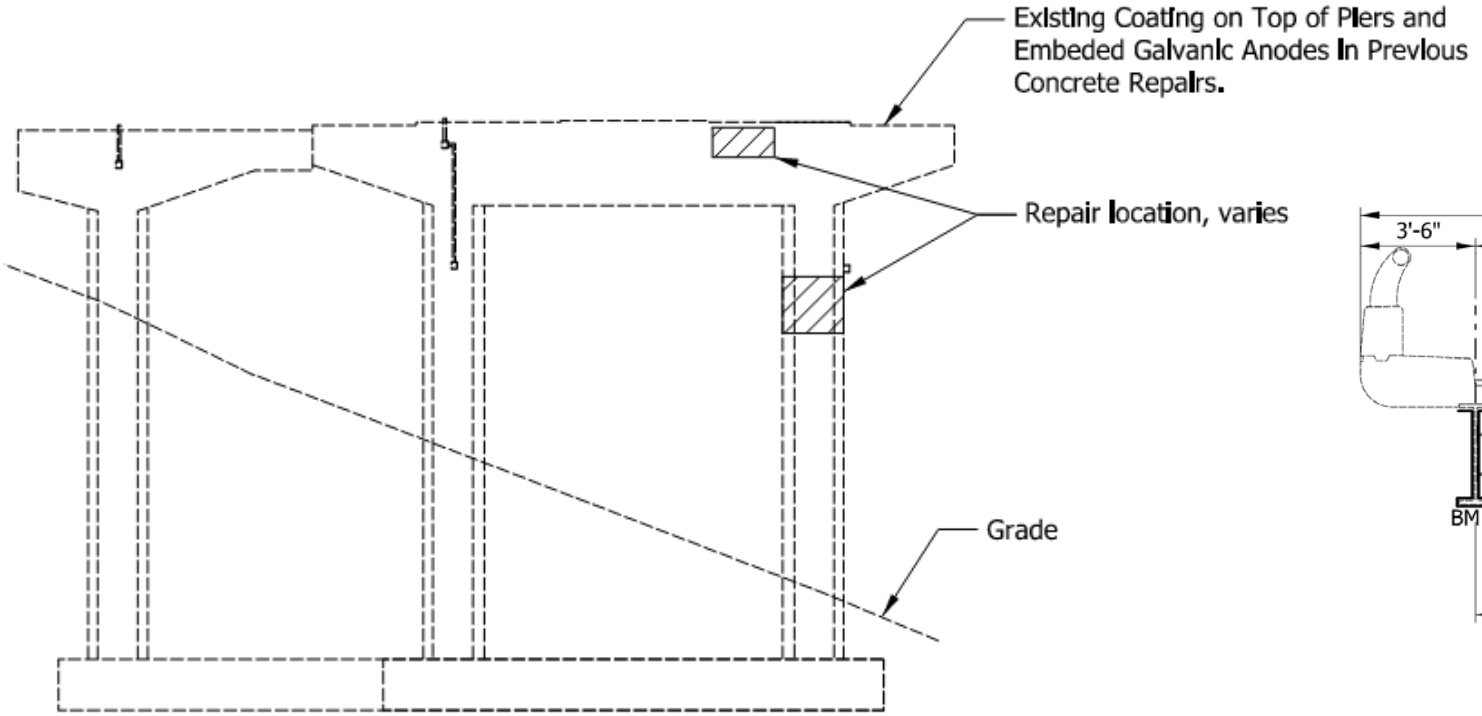
Joint Removal and “Link Slab” Installation

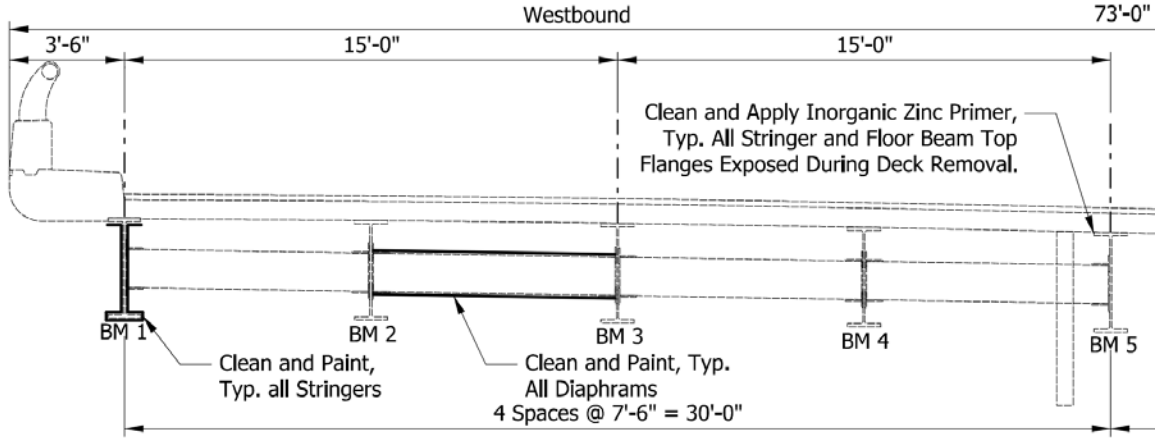




➢ **Pot Bearing Installation**

Holistic Considerations for Structure Rehabilitation





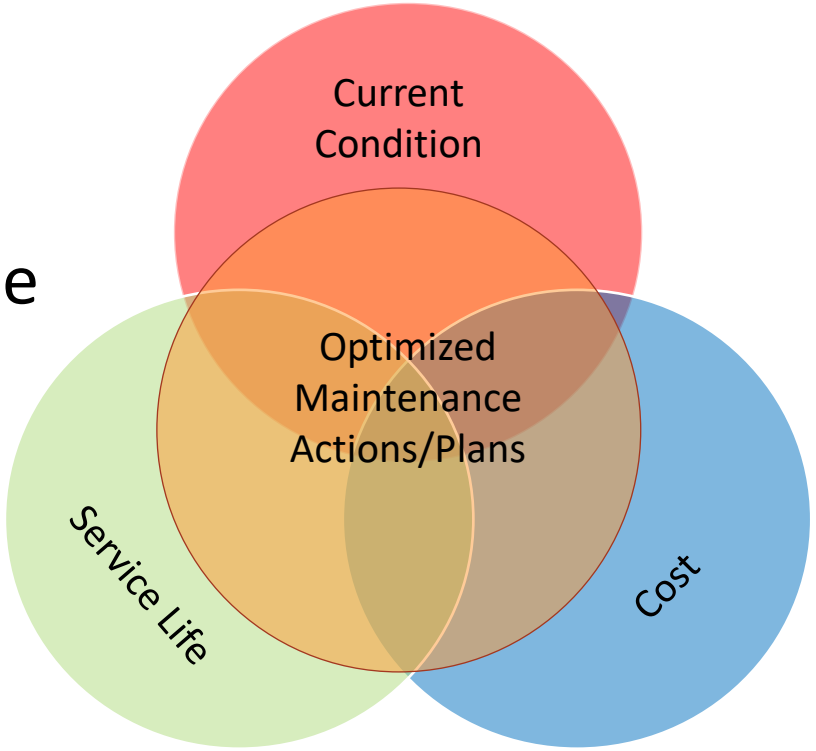
- Substructure Repairs
- Steel Repair and Painting

Substructure Repair

Steel Re-Coating

Closing Thoughts

- Characterization of Current Condition of structure is essential for selecting appropriate preservation/maintenance activities
- Service Life Modeling and Life-Cycle Cost Analysis are of paramount importance to find optimal solution(s)
- NDE and Material Sampling can be used to better assess the condition of a bridge deck beyond visual and sounding alone



Acknowledgments

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Questions?

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