SOLUTIONS FOR THE BUILT WORLD

JFK Causeway

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WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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Principal at WJE, 2013 – present
TxDOT: 1986 – 2013
    State Bridge Construction &
    Maintenance Engineer: 2000-2013
ASBI member since 2000

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ENGINEERING RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

Purpose and Learning Objectives

Purpose

This presentation provides an educational forum that will focus on a few of the latest innovations and technologies in the construction industry.

At the end of this presentation you will be able to:

Understand the design and construction history of the bridge

Understand the service life implications of the assessment findings

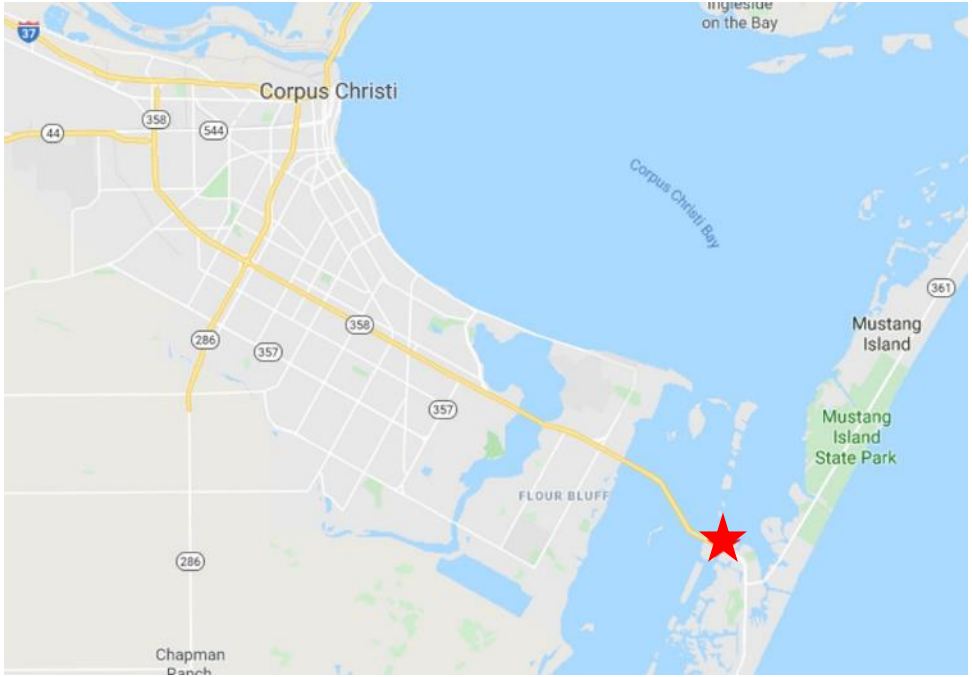
Utilize lessons learned from this project to improve future designs

Presentation Outline

- Bridge History
- Design Challenges
- Construction Challenges/Issues
- Condition Assessment Findings
- Service Life Discussion
- Lessons Learned

1930’s Causeway

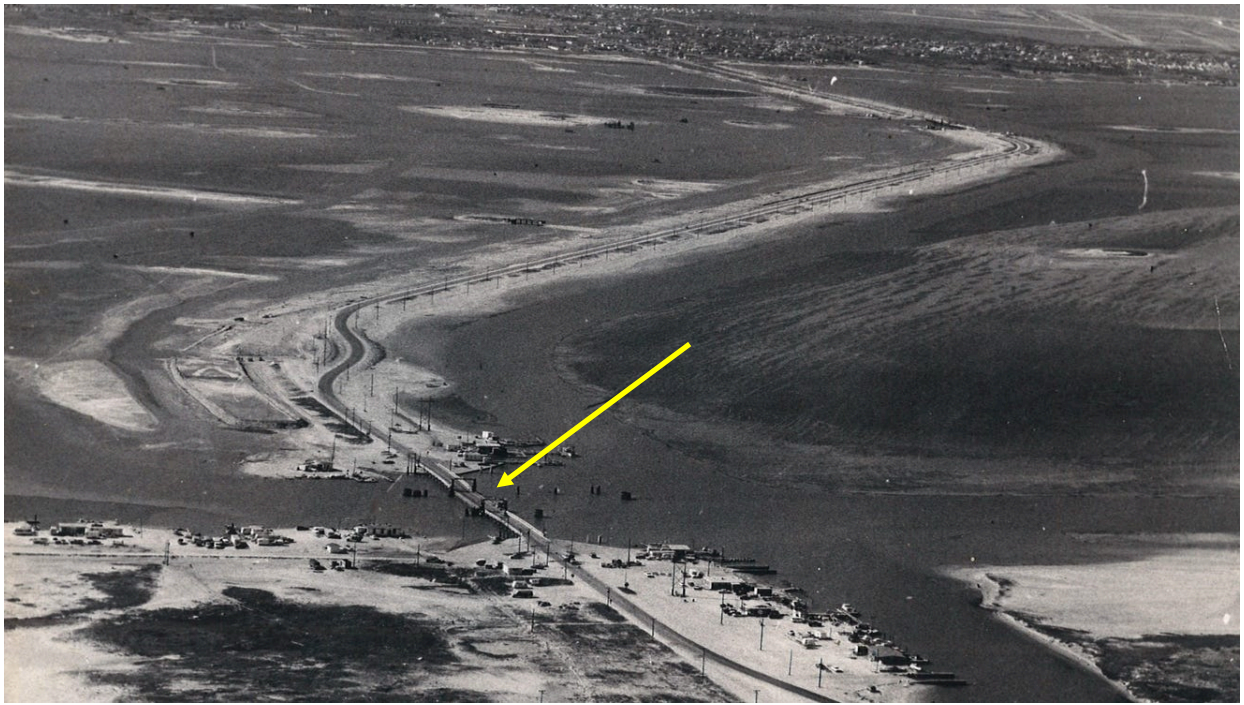
Bridge History



Bridge History

- Original 2-lane toll road built 1950
  - Only bridge crossing to Mustang Is.
  - Had two swing barges across channels
- New 4-lane roadway opened in 1973
  - $2.5M
  - 83ft above the GIWW
  - 1st Precast Segmental Bridge in US

Bridge History



1950 Causeway

Bridge History

- Designed by the University of Texas: Dr. John E. Breen, PhD, PE
- TxDOT Designer: Alan B. Matejowsky, PE (1944 – 2013)
- Designed based on1/6 scale model
  - Creep/shrinkage effects
- Construction proof of concept
  - Meetings with contractors at lab
- Discussions with Jean Mueller

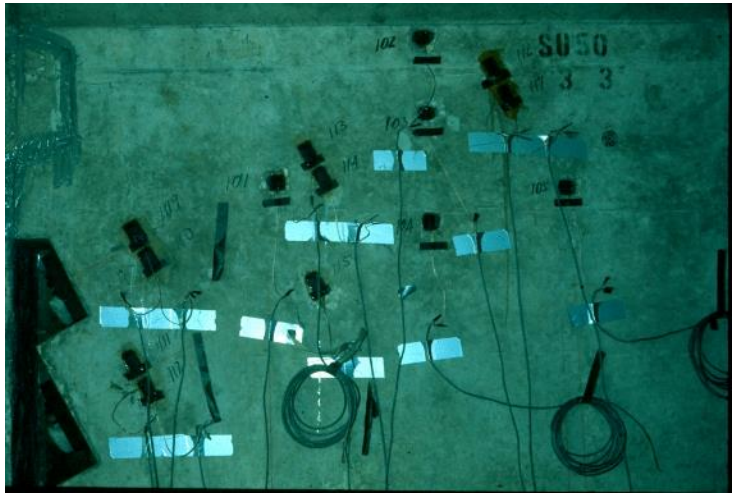
Bridge History

Research Reports (https://ctr.utexas.edu/library/reports/)

- Long Span Prestressed Concrete Bridges of Segmental Construction: State of the Art (0-121-1, 1969)
- Epoxy Resins for Jointing Segmentally Constructed Prestressed Concrete Bridges (0-121-2, 1974)
- The Design and Optimization of Segmentally Precast Prestressed Box Girder Bridges (0-121-3, 1975)
- Computer Analysis of Segmentally Erected Precast Prestressed Box Girder Bridges (0-121-4, 1974)
- Construction and Load Tests of a Segmental Precast Box Girder Bridge Model (0-121-5, 1975)
- Minimizing Construction Problems in Segmentally Precast Box Girder Bridges (0-121-6F, 1975)

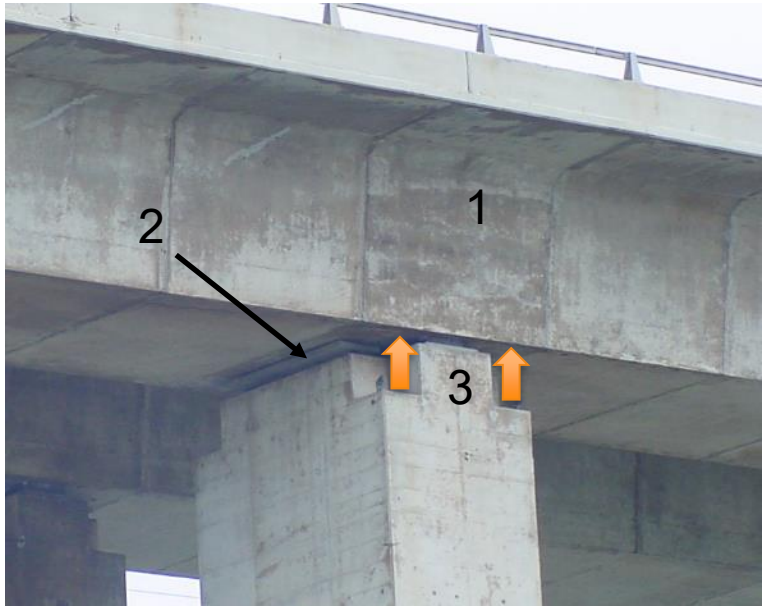
Design Challenges

- AASHTO/US Industry Guidance missing or insufficient for:
- PT anchor zones
- Friction/wobble coefficients
- Epoxy joining of segments
- Geometry control
- Creep/Shrinkage
- No design software

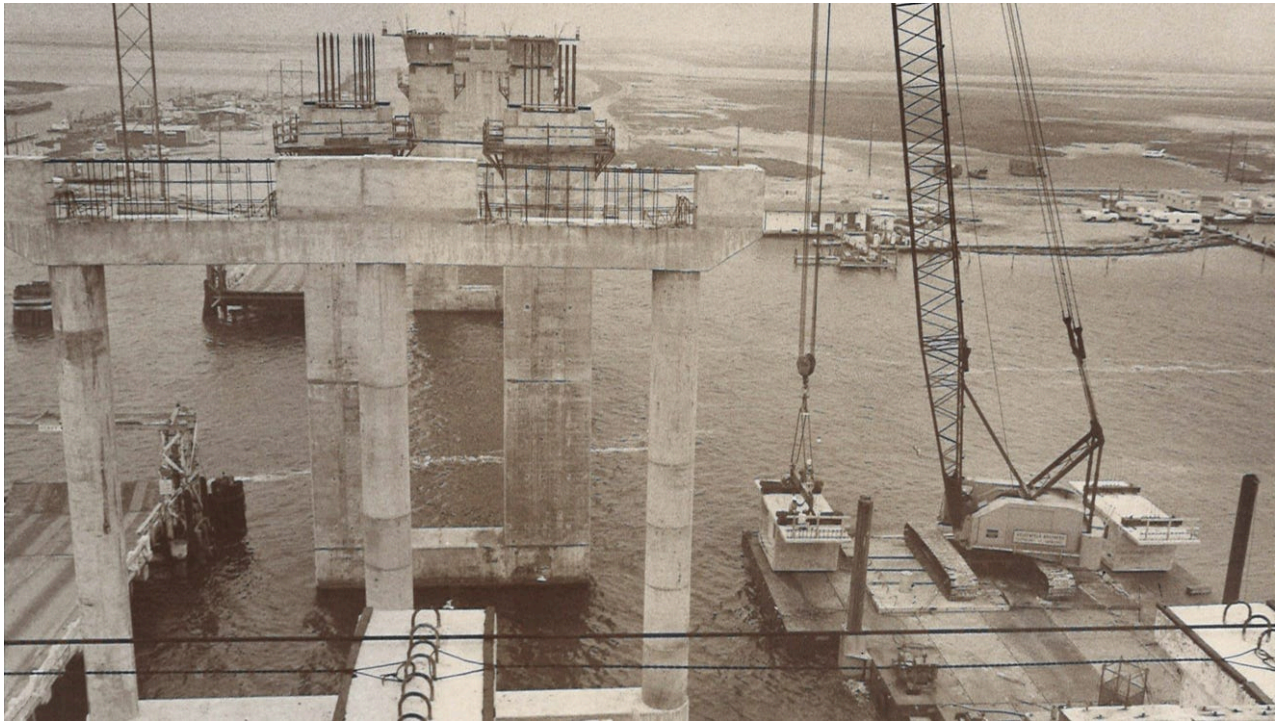


Design Aspects

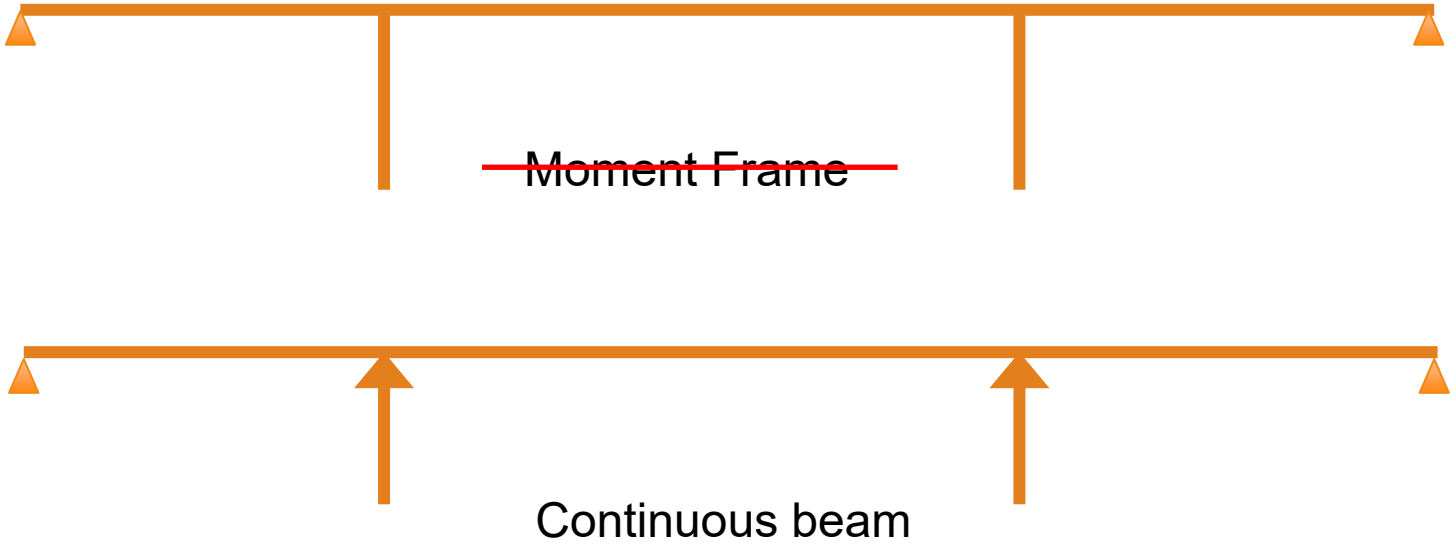
1. Full segment out of balance
2. Temporary connections to piers: Tie downs
3. Load balancing with simple neoprene bearings
4. Grouted within 48 hours of stressing



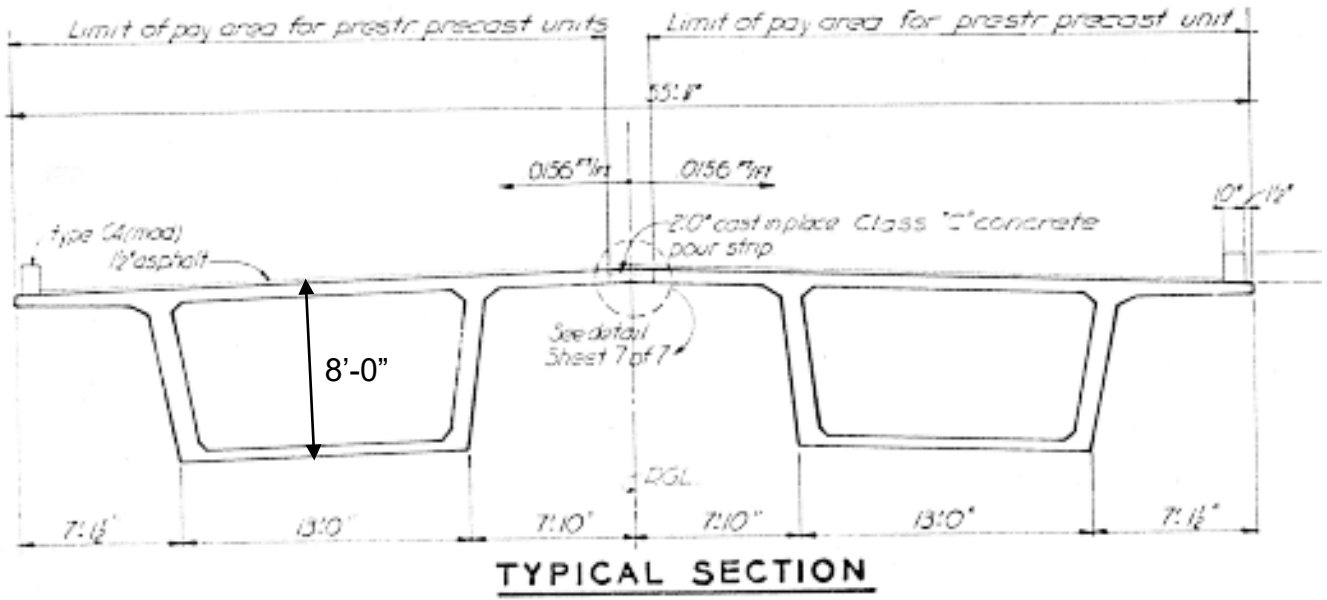
Design Aspects



Design Aspects: “Simplicity”

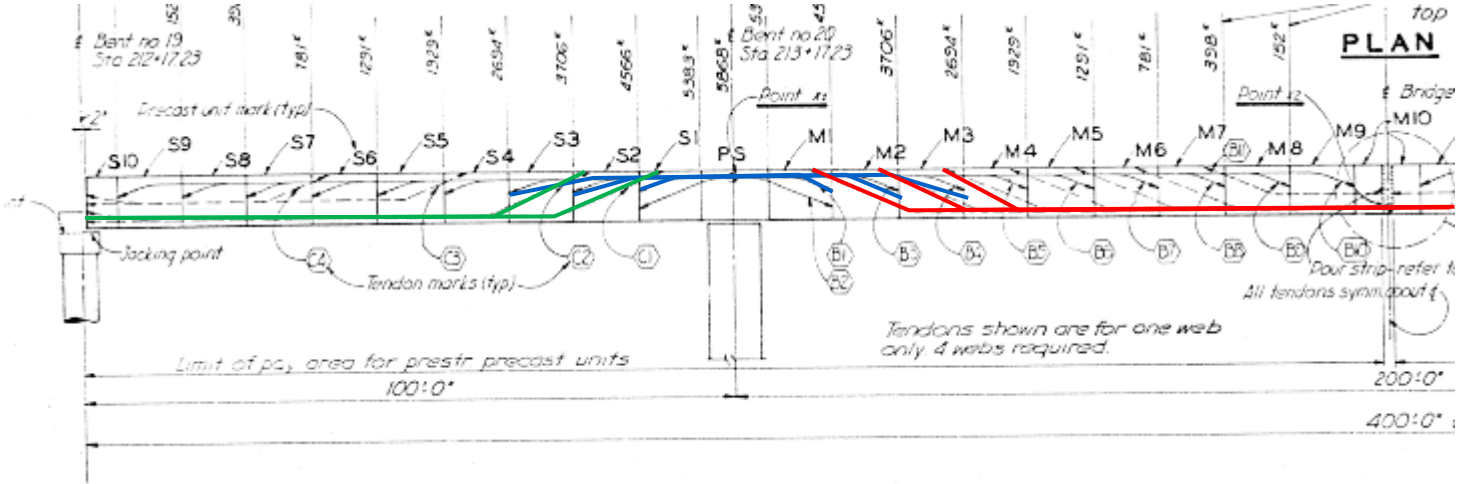


Design Details



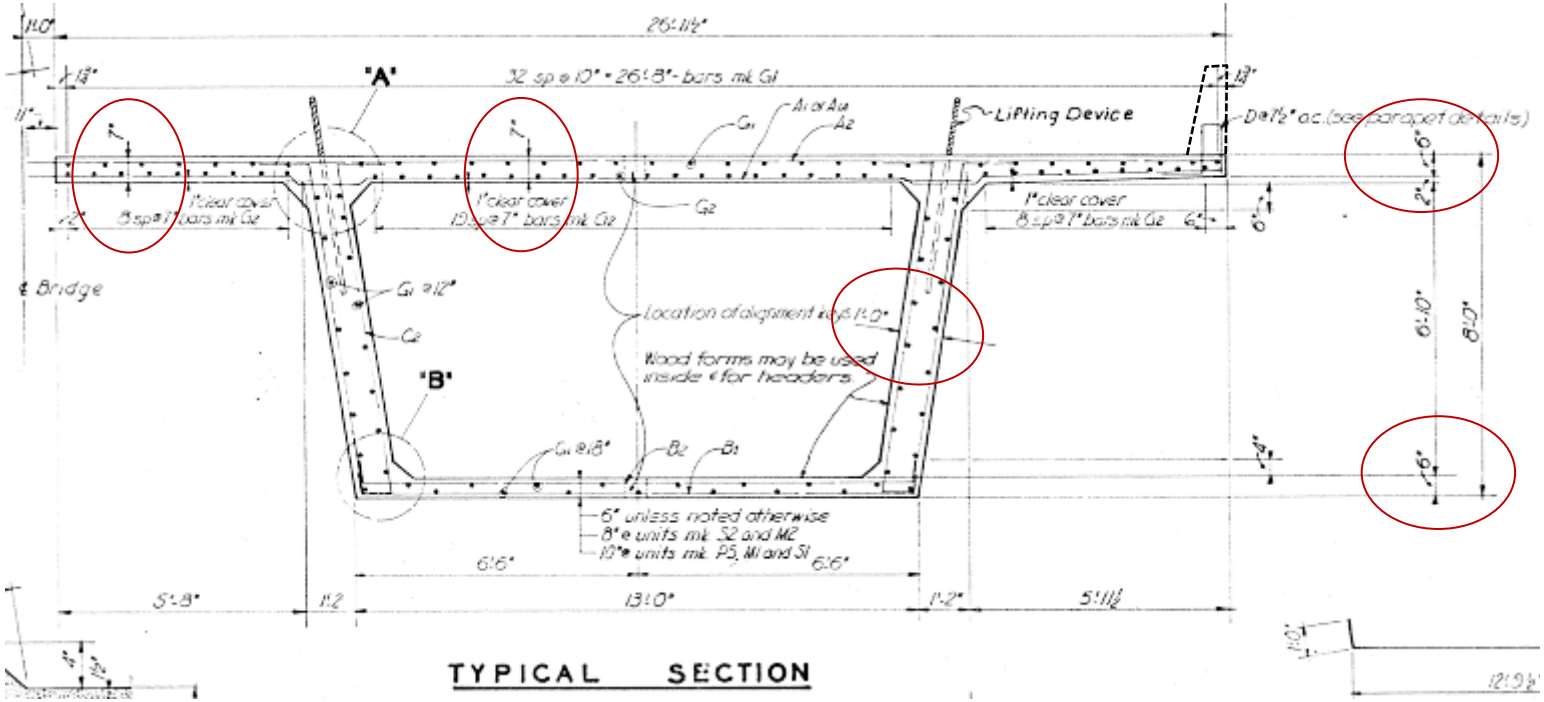
TYPICAL SECTION

Design Details



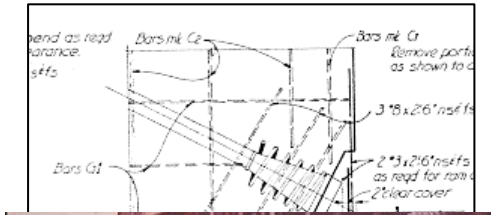
Half Elevation : Tendons

Design Details

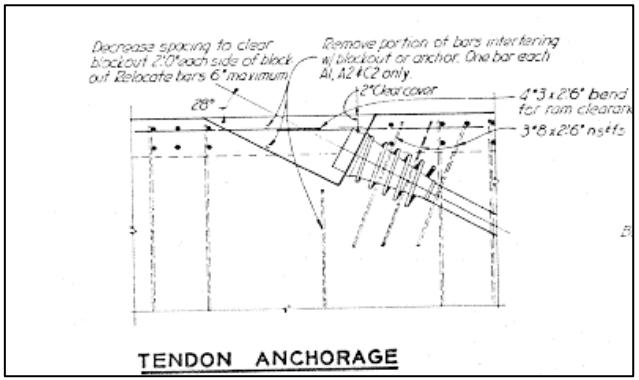


Design Details

Cantilever Tendons

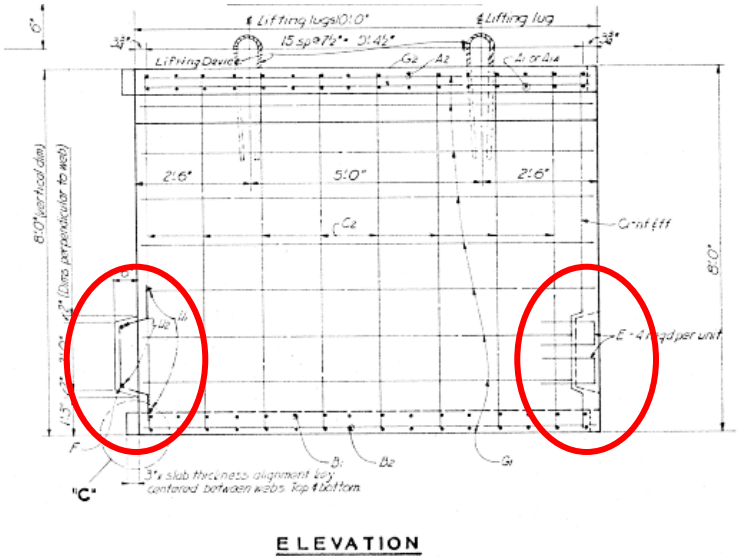


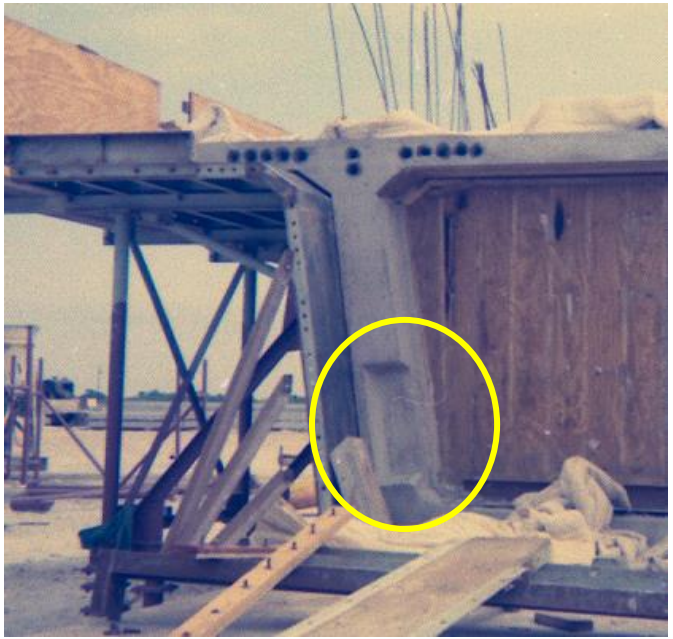
Continuity Tendons



Design Details

Single Large Shear Key



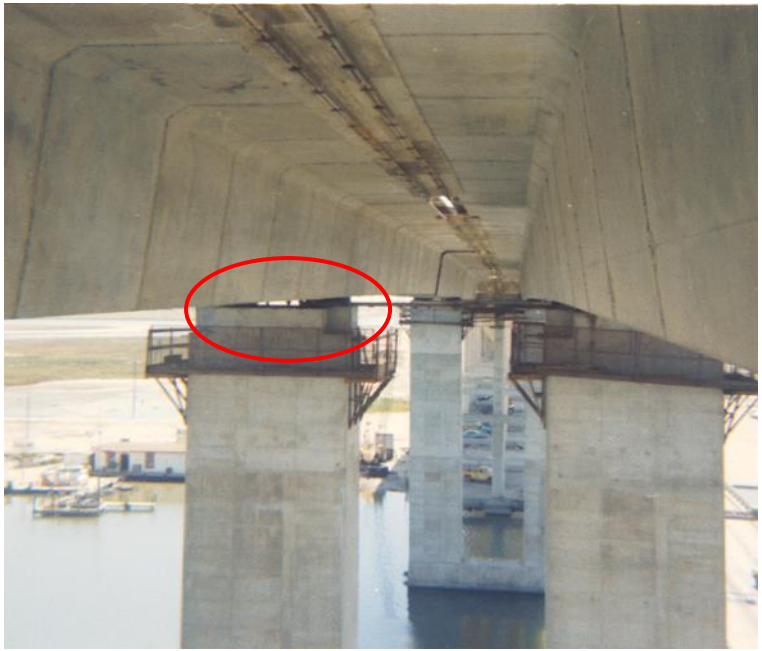


Construction Challenges

- Balanced cantilever – full segment out of balance
- Segment Delivery/Erection
- Epoxy application
- Duct alignment/“pullout”
- Segment cracking

Construction Challenges

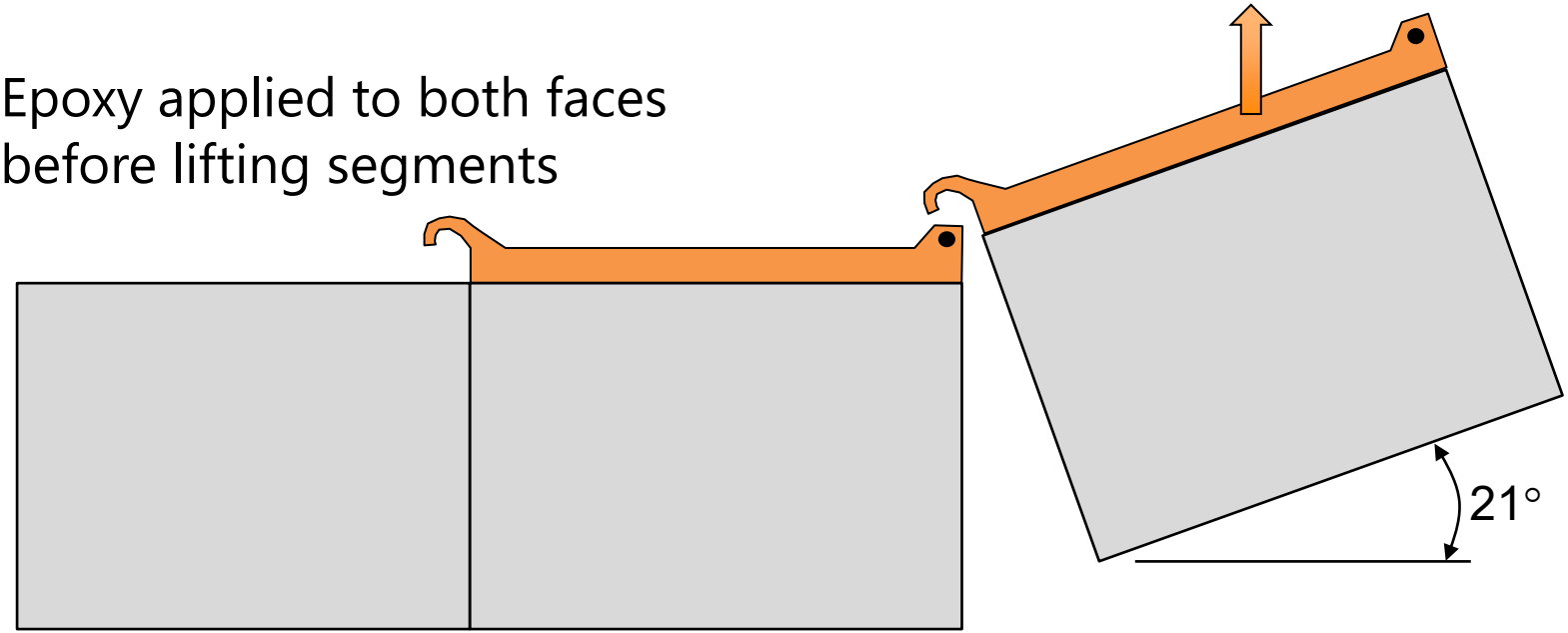
- Balanced cantilever – full segment out of balance
- Temporary hold-down bars (not Post Tensioned)
- Nuts periodically loosened



Construction Challenges

Segment Delivery: 1 Barge Mounted Crane + Custom Hardware

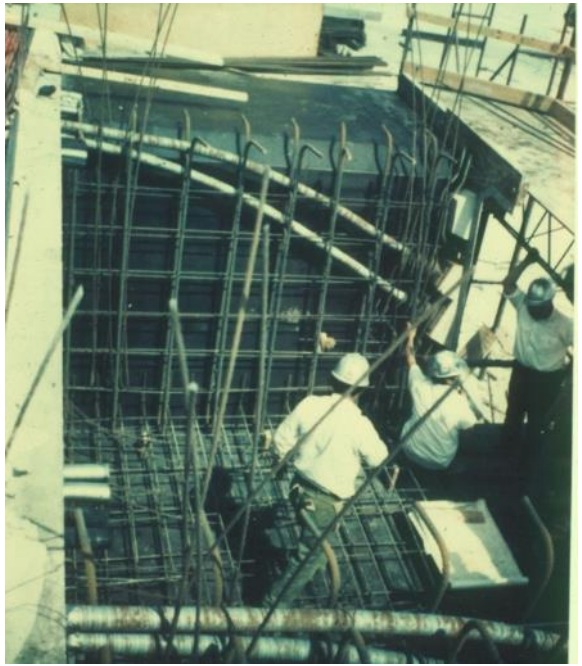
Epoxy applied to both faces
before lifting segments



Construction Challenges

Duct Alignment

- Used thin-walled metal ducts
- Insufficient attachment to rebar
- No inflatable alignment tubes
  - High friction values
  - Replace several tendons due to installation trouble
  - Tendon blockage/duct pullout



Construction Challenges

- Web cracking at cantilever tendons
- All 88 segments cast when discovered
- Project shut down 9 months for study

Cracking caused by:

- Anchorage geometry changes
- Insufficient local zone reinf.
- Other rebar cut for tendons
- Did not affect capacity – epoxy seal

Condition Assessment – Scope

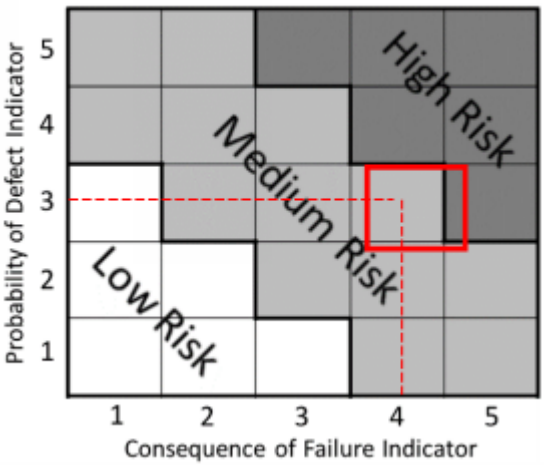
- Review Plans/Reports
- Visual inspection of 100% of interior/exterior
- Locate PT/anomalies using NDE: GPR, IE, UST
- Inspect grout and tendon conditions
- Sample grout

Condition Assessment – Scope

- Service Life Modeling
  - Cores for chloride testing/petro
  - Clear cover survey – GPR
  - Half-cell corrosion potential – selected locations
  - Corrosion rate – selected locations
- Goal: 30 Year Extension

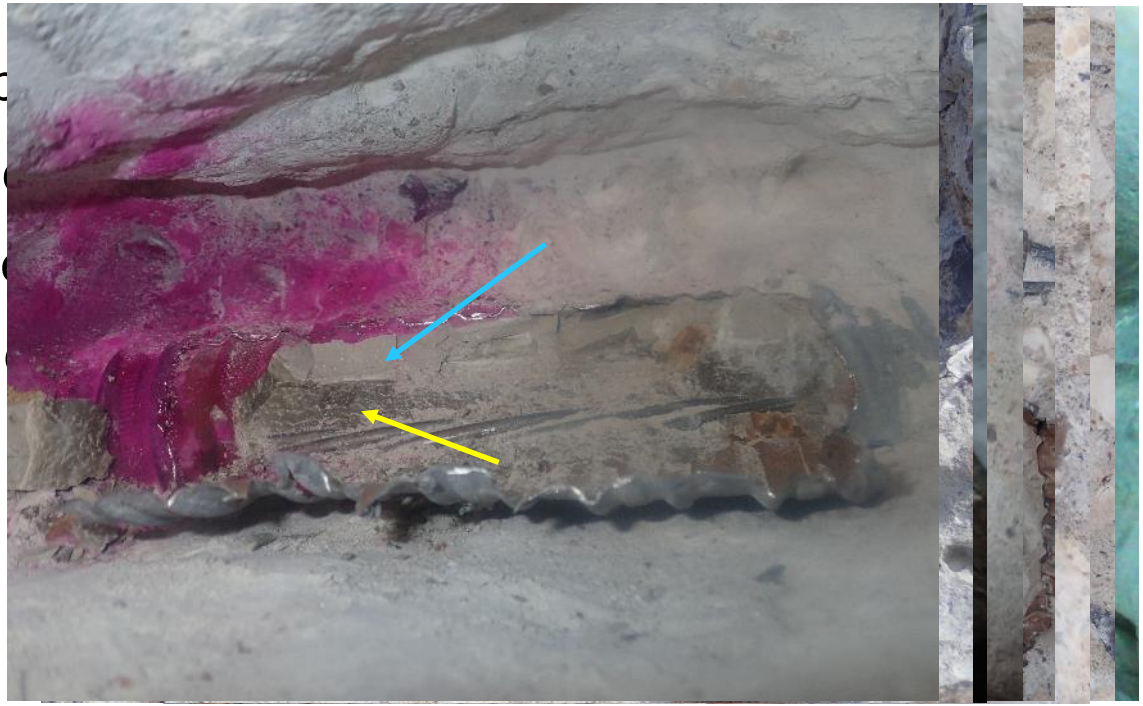
PT Assessment

- Statistical approach per FHWA-HRT-13-028
- Pre-selected locations
  (not random – limited to outside lanes)
- 75% Confidence level per TxDOT
  - 6 Cantilever tendons
  - 6 continuity tendons: deck anchors + interior locations
  - Borescope + Invasive openings
    (all were internal tendons)



Assessment Findings – PT System

- Only one anomaly typ
- Two grout voids foun
- Strands were in like n
- Evidence of regroutin
- Pictures…



Visual Assessment Findings

Exterior:

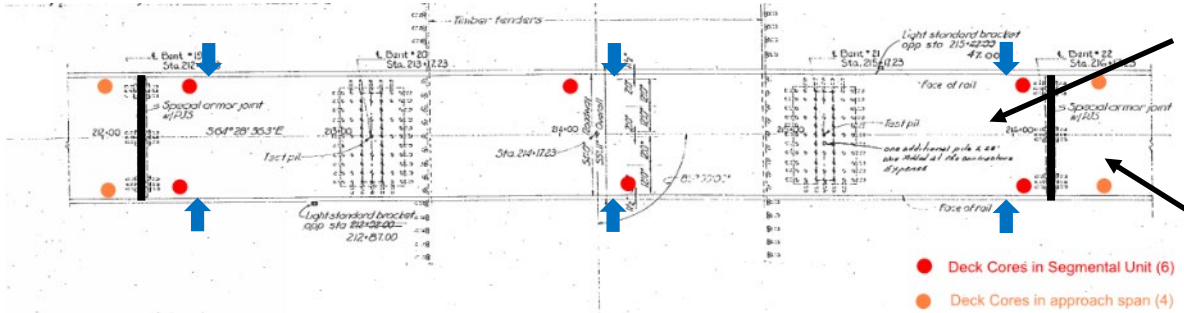
- Cracking in web
  epoxy seals intac
  cracks)
- Spalling of end t
- Corrosion/spallir
  - Pictures…

Visual Assessment Findings

Interior

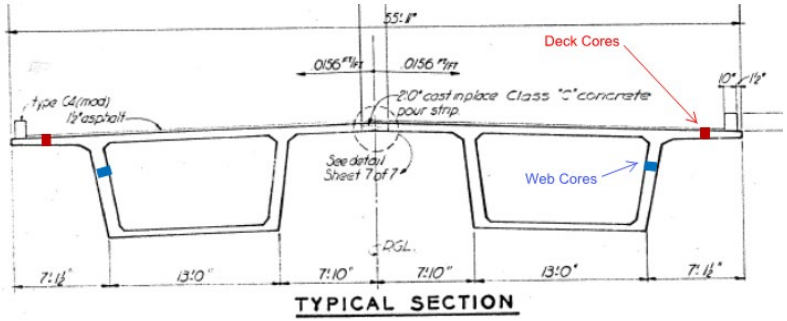
- Diaphragm cracking
- Web cracking
- Moisture at deck anch
- No Joint Leakage

Service Life Results



2.5” + Asphalt

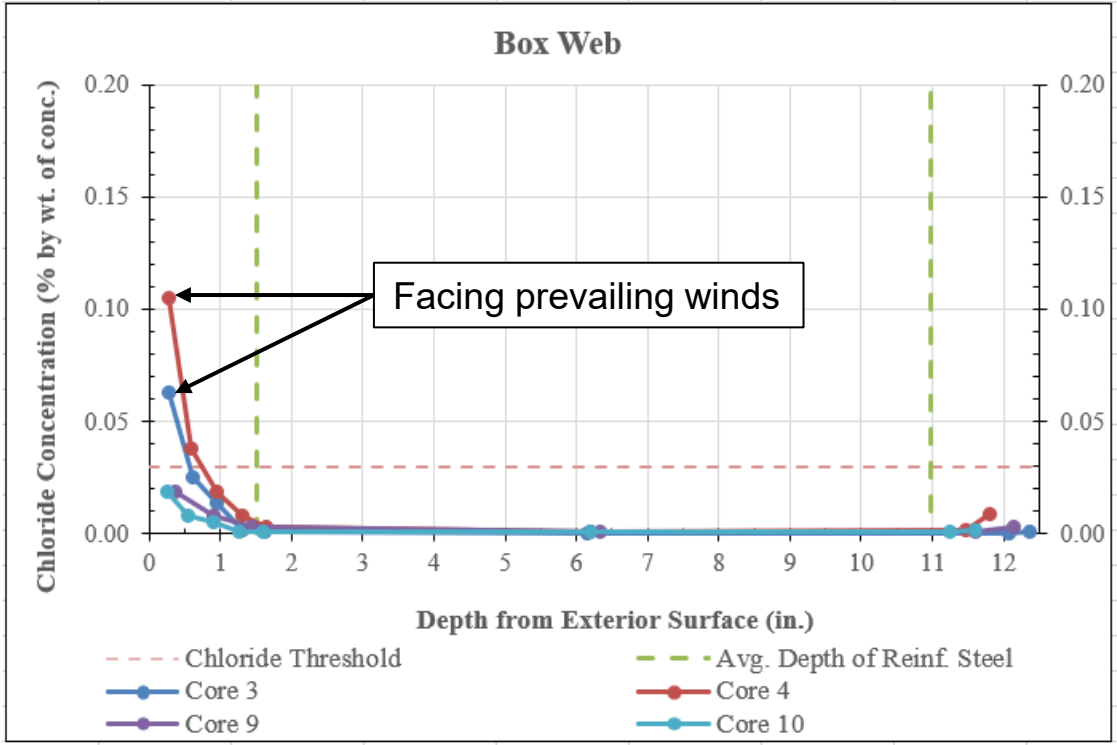
Bare deck



Coring Locations – 16 cores

Chloride profiles - Webs

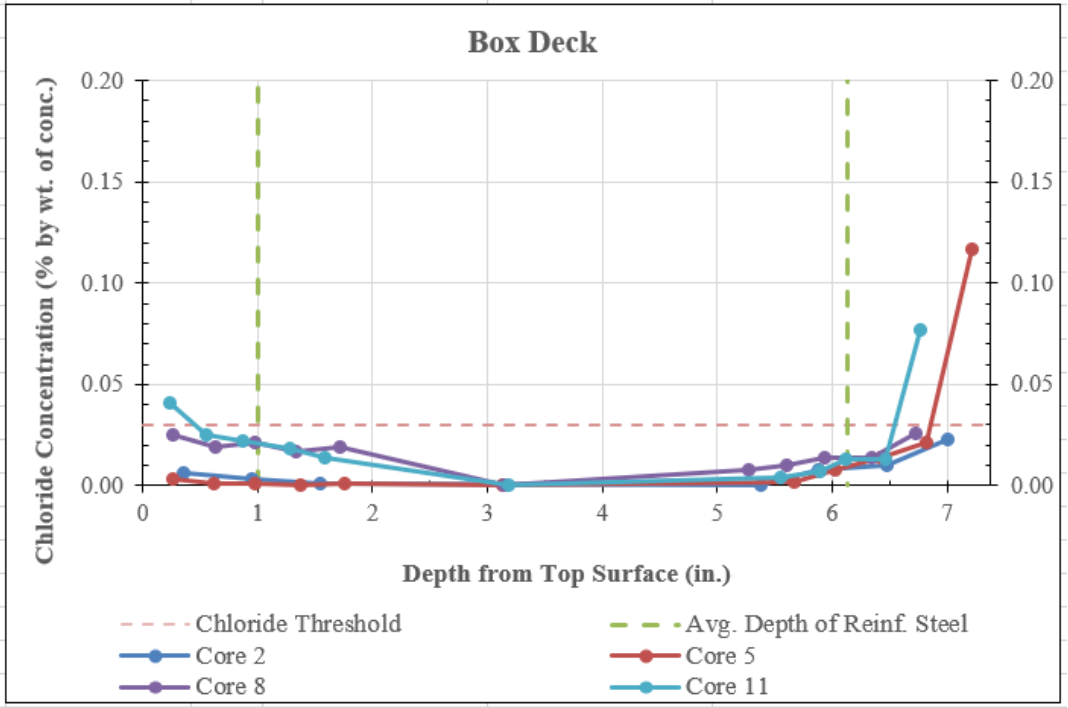
Exterior Face



Interior Face

Chloride profiles – Top slab

Top - Under Asphalt

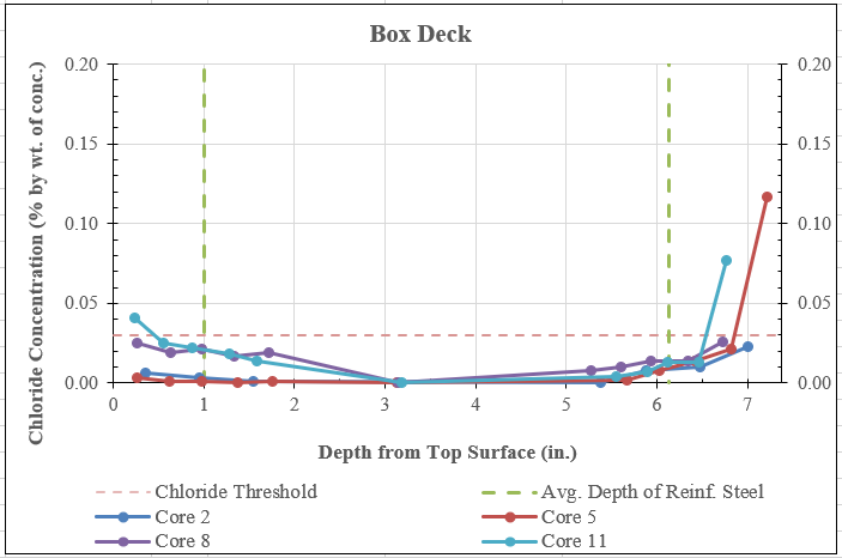


Wing Underside

Chloride profiles – Approach Slabs

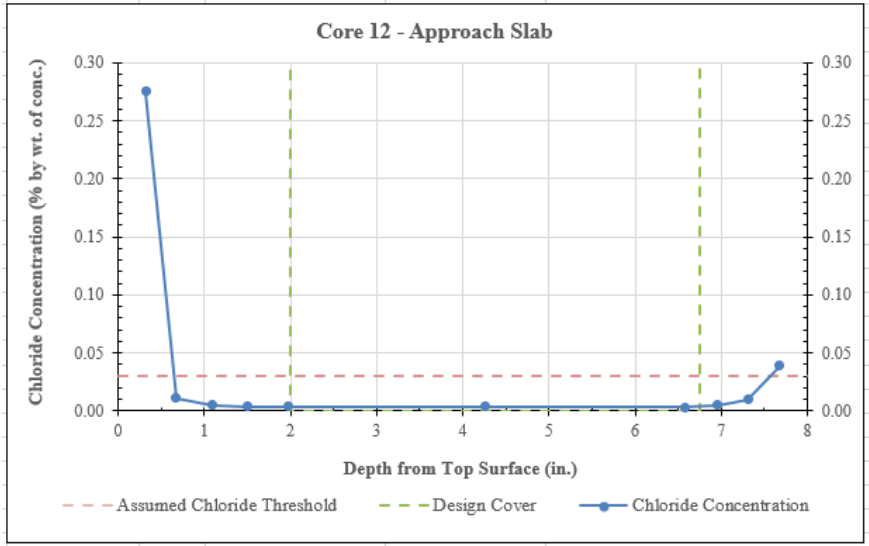
Top

Underside



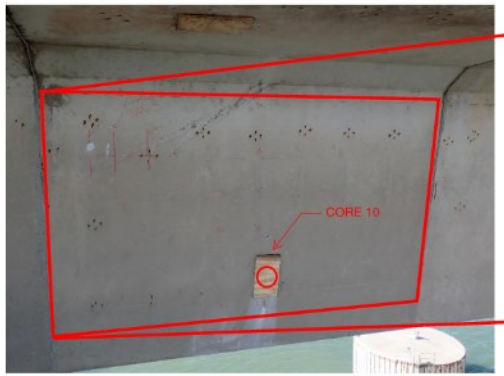
Top

Underside

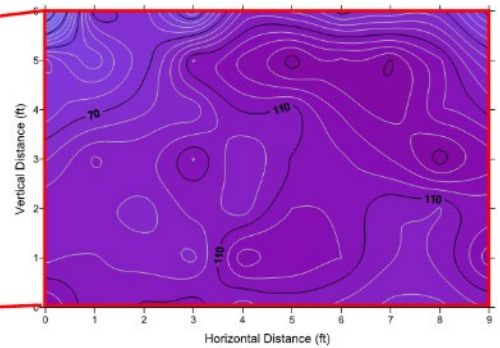


Service Life Considerations

- Design Clear Cover:
  1″ top slab/wings
  1.5″ for webs and bottom slab
- Black Rebar
- Std. Concrete mix
- No external coatings



ASSESSMENT LOCATION OVERVIEW



HCP DATA CONTOUR PLOT

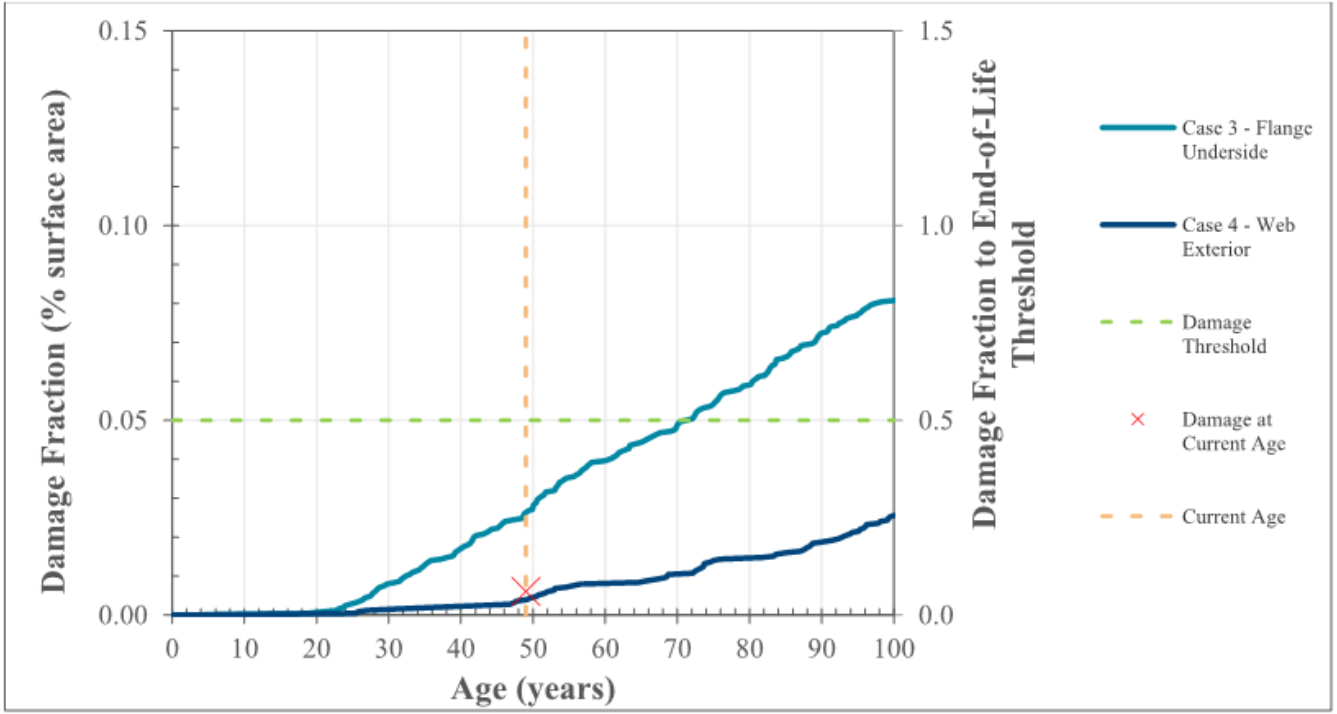
Service Life Considerations

Exposure Zones/Cases:

1. Deck surface in EB lanes: better overlay w/ membrane
2. Deck surface for WB lanes: older overlay, no membrane
3. Underside of wings
4. Webs/bottom slab

- Clear cover to rebar matched plan dimensions
- “extra” steel installed did not often match clear covers
- Wind direction affected chloride exposure
- ACP Overlay protects deck

Service Life Results



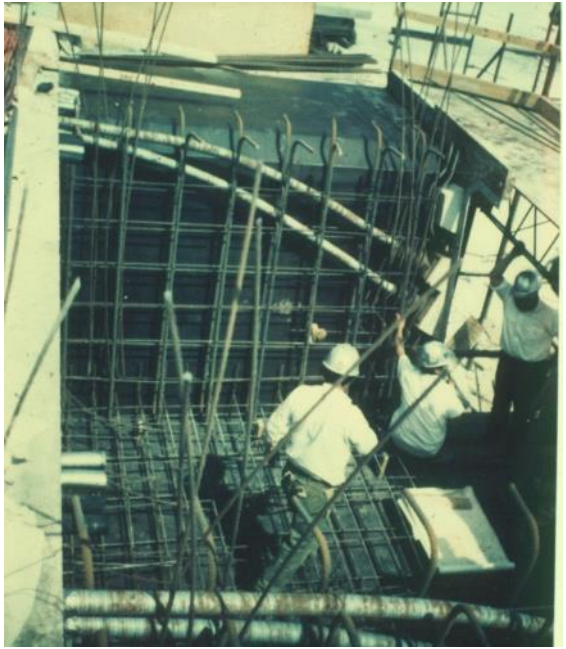
Rehabilitation Recommendations

- Replace overlays using membrane or use Polyester Polymer Concrete (PPC)
- Replace expansion joints
- Spot repairs to isolated spalling/cracking
- Water-repellant coating to exposed exterior surfaces
- Replace end tendon anchor pour-backs
- Possible cathodic protection system to piers

Lessons Learned

Research Report 6

- Improved anchor zone reinf. provisions (mock-ups)
- Increase element dimensions (slabs/webs) to improve constructability – but adds weight
- Needed better moment connection at piers
- Locate tendon anchors outside the webs (blisters)
- Robust ducts
- Multiple, Castellated shear keys better



Lessons Learned – Assessment Findings

- No substitute for clear cover
- Protect end anchors near expansion joints
- Epoxy – both faces
- Pay attention to grouting (they did)
- QC for segment production
- Tendon anchors in deck could cause problems

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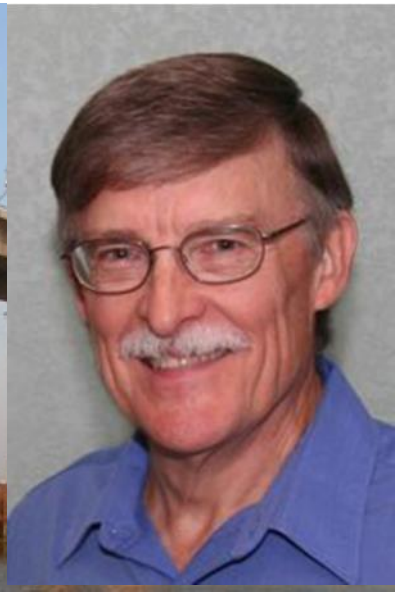
This concludes the educational content of this activity



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