National Concrete Bridge Council

2026 NCBC WEBINAR SERIES

Introduction to the Design Process for Segmental Bridges with the New ASBI Segmental Design Manual

March 18, 2026

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Update from the National Concrete Bridge Council

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NCBC Webinar Series 2026

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April 15: Stress–Strain Behavior and Bridge Performance of Concrete Containing Expanded Shale, Clay, and Slate Aggregates

May 20: Anchoring to Concrete Updates for 2026-

Part 1: Screw Anchors

June 10: Overview of the new M-50 Tech Note on Unducted Post Tensioning with Epoxy Coated Strand

July 15: Anchoring to Concrete Updates for 20206-

Part 2: Attachments with Shear Lugs

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Industry Events 2026

Mar 29- Apr 1: ACI Concrete Convention, Rosemont, IL

Apr 13-16: CRSI Technical Meeting, Napa, CA

April 14: TRANS-IPIC UTC Workshop, Rosemont, IL *(handout)*

Apr 23-24: NCBC Seminar, Austin, TX *(handout)*

April 27-28: Concrete Materials for Bridges Training (CBEI)

May 4-7: PTI Convention, Long Beach, CA

May 19-21: Bridge Deck Construction Inspection Program (CBEI)

Jun 15-17: International Bridge Conference, National Harbor

Jun 28- Jul 2: AASHTO COBS Annual Mtng,Charlotte

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- ICRI – Concrete Repair – Restore | Repurpose | Renew
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- PCI
- pti
- SFA
- SSIG – Stainless Steel Interest Group

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Acknowledgements

Each month a member goes above and beyond to help deliver this continuing education program. Webinars are suggested and sponsored by various members who dedicate their time and energy to provide a diverse range of speakers and topics for our audience.

In February, the Silica Fume Association helped to bring an engineer economist to discuss the Life 365 App and how to estimate service life of concrete mix designs and corrosion protection systems.

Today, ASBI enlisted two experts to Introduce the new ASBI Design Manual and review the design process for concrete segmental bridges.
Thank you to these, and to all the members who enable us to host this free webinar program. Their assistance is sincerely appreciated.

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The views and opinions expressed in this presentation are the presenters' and do not necessarily reflect those of NCBC.

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About the Presenters

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Hardesty & Hanover, Denver, CO

American Segmental Bridge Institute

Introduction to the Design Process for Segmental Bridges with the New ASBI Segmental Design Manual

March 18, 2026

Learning Objectives

- Navigate the structure and key resources within the new ASBI Segmental Design Manual.
- Identify the appropriate segmental bridge type based on span range and site constraints.
- Understand the fundamental workflow for preliminary and final segmental design.
- Recognize the benefits of segmental construction regarding schedule, durability, and cost-effectiveness.

Marc Basnight Bridge
Oregon Inlet, NC

Intent of presentation is to give an overview of the process to design a segmental bridge and showcase how the new ASBI Design Manual helps with these efforts.

Overview

Concept Development and Preliminary Design (Ch 1- 3)

Longitudinal Analysis and Design (Ch 4)

Transverse Analysis and Design (Ch 5)

Design of Tendon Anchorages and Diaphragms (Ch 6)

Segment Detailing for Post-Tensioning (Ch 7)

Design for Durability and Serviceability (Ch 8)

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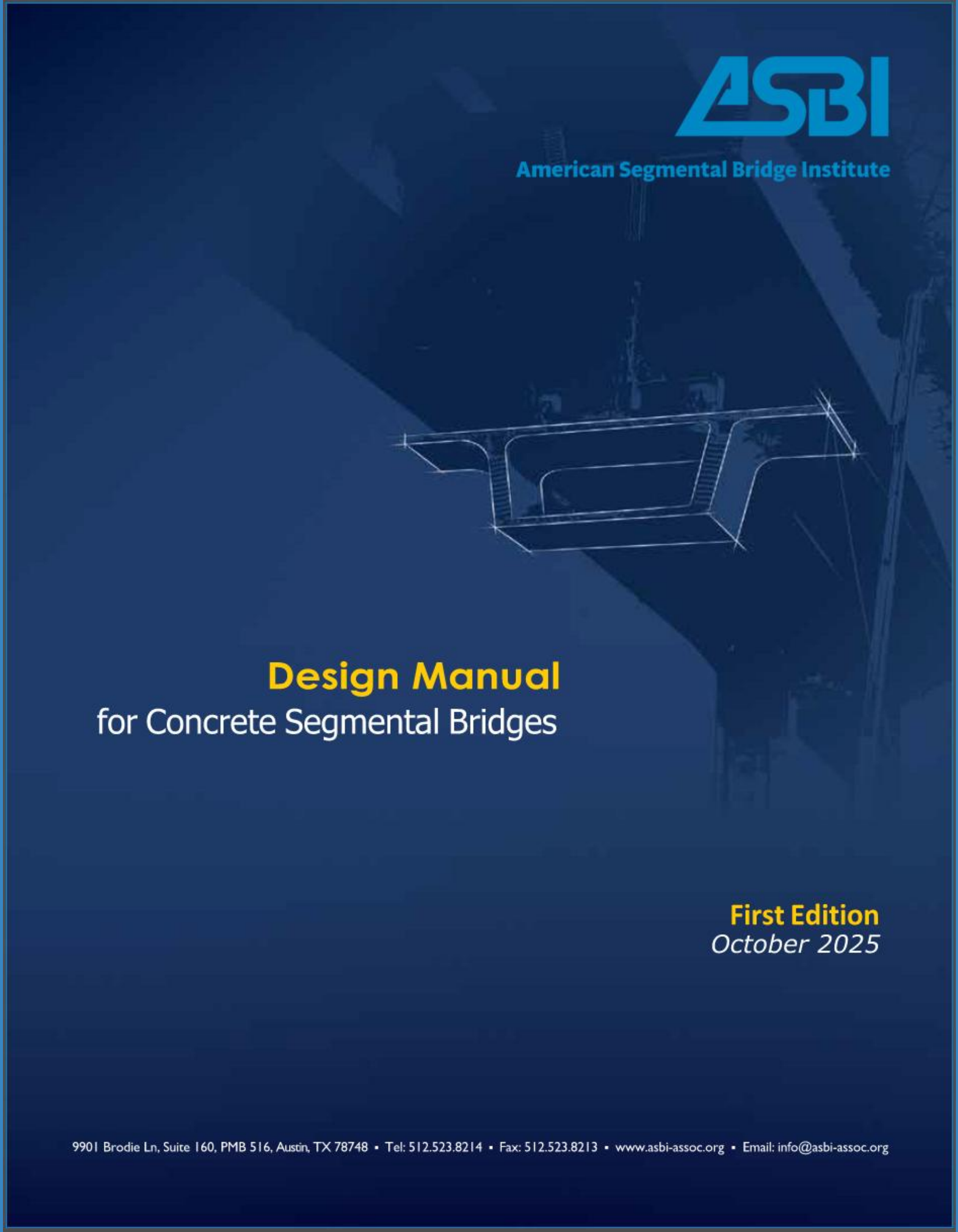
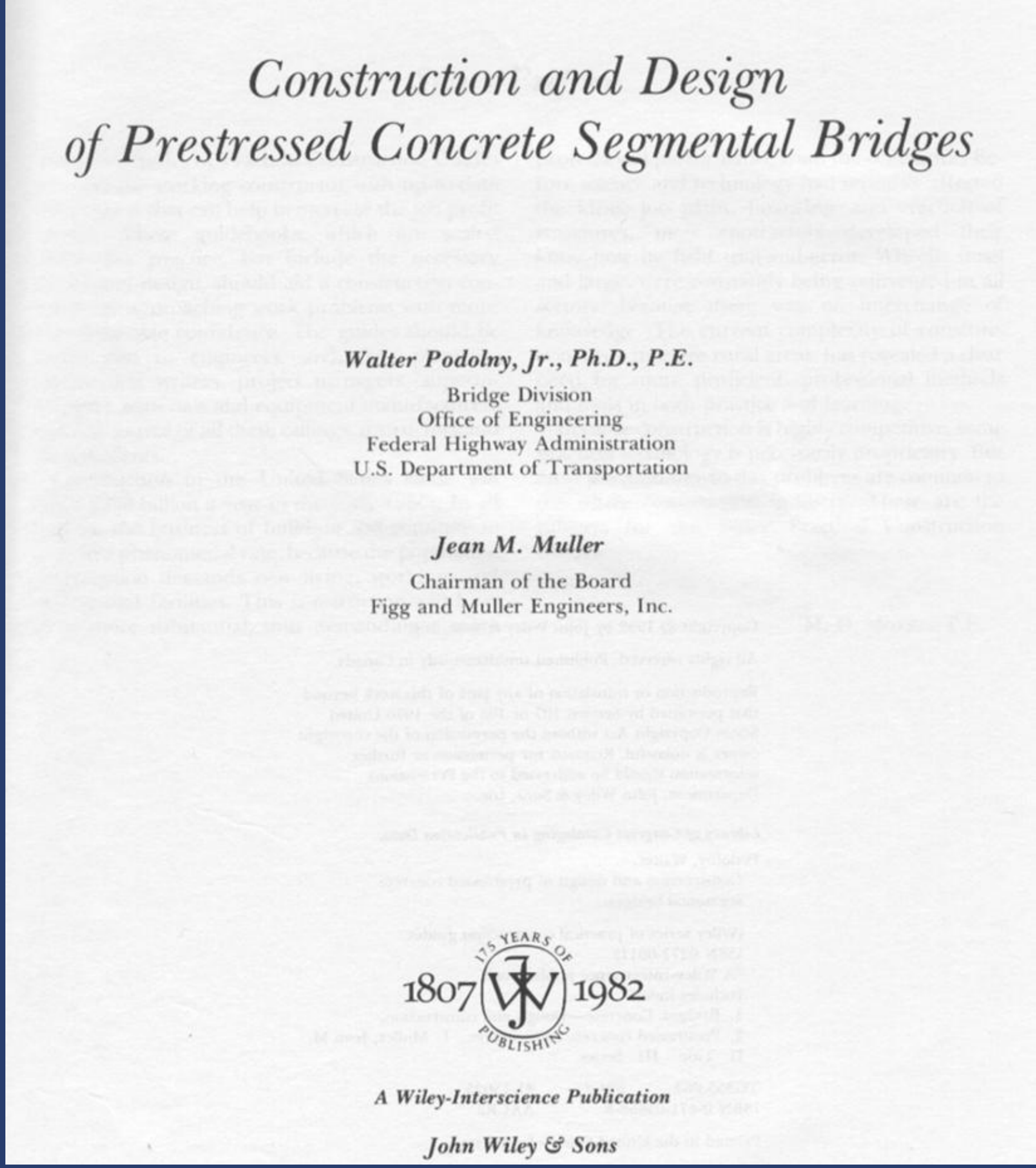


Concept Development and Preliminary Design

We Stand on the Shoulders of Giants

- The ASBI Design Manual is documented with numerous reference resources.
- Podolny & Muller's *Construction and Design of Prestressed Concrete Segmental Bridges* is one of the older references in the Design Manual and many engineers' initial reference for segmental bridges



Construction and Design of Prestressed Concrete Segmental Bridges

Walter Podolny, Jr., Ph.D., P.E.
Bridge Division
Office of Engineering
Federal Highway Administration
U.S. Department of Transportation

Jean M. Muller
Chairman of the Board
Figg and Muller Engineers, Inc.

175 YEARS OF PUBLISHING 1807 1982

A Wiley-Interscience Publication

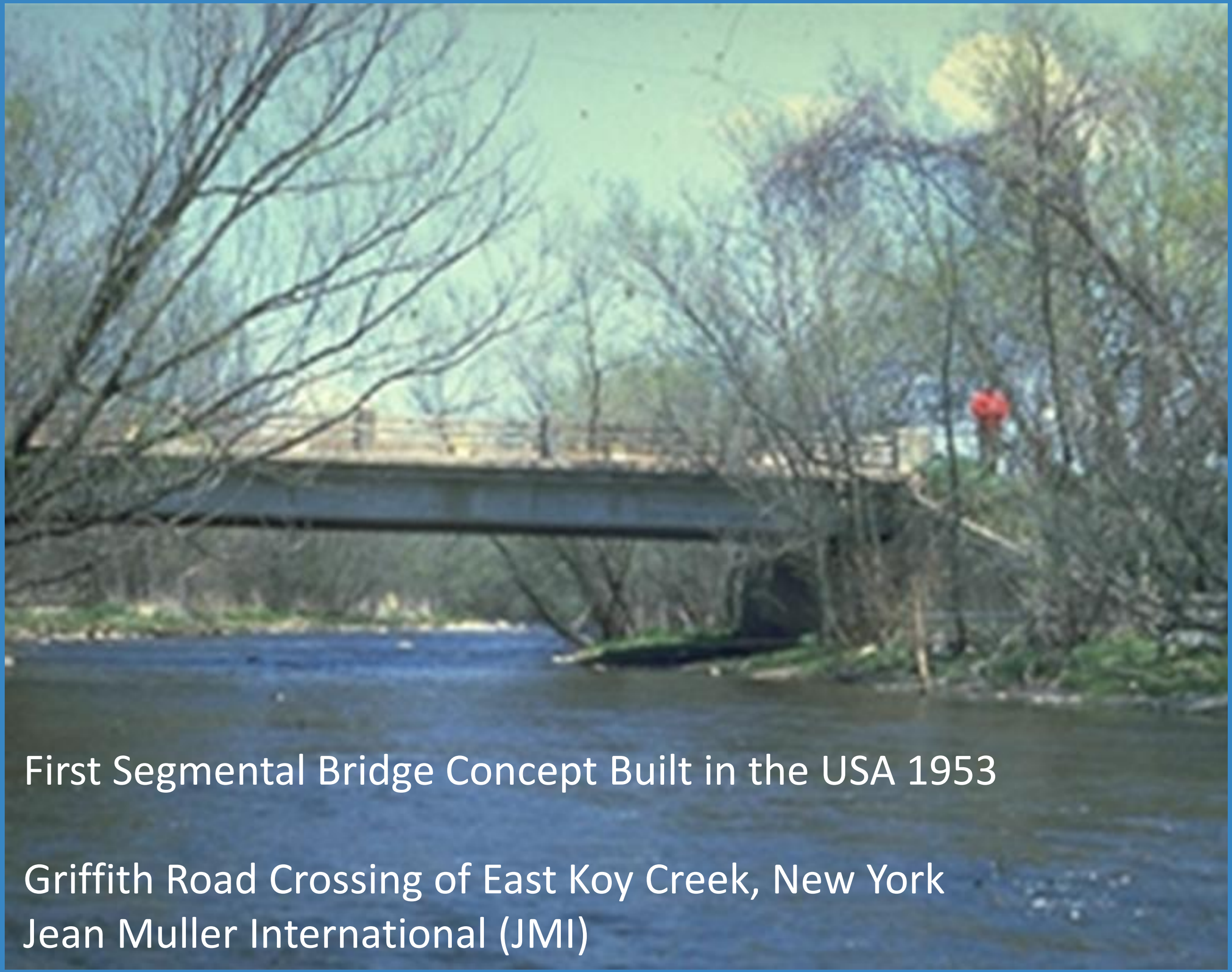
John Wiley & Sons

History of Segmental Bridge Construction

Segmental bridge construction began in Europe in late 1940s

Technology introduced in the US in 1950s

More modern uses of segmental technology began in the 1970s with Memorial Causeway bridge (Corpus Christi, TX)



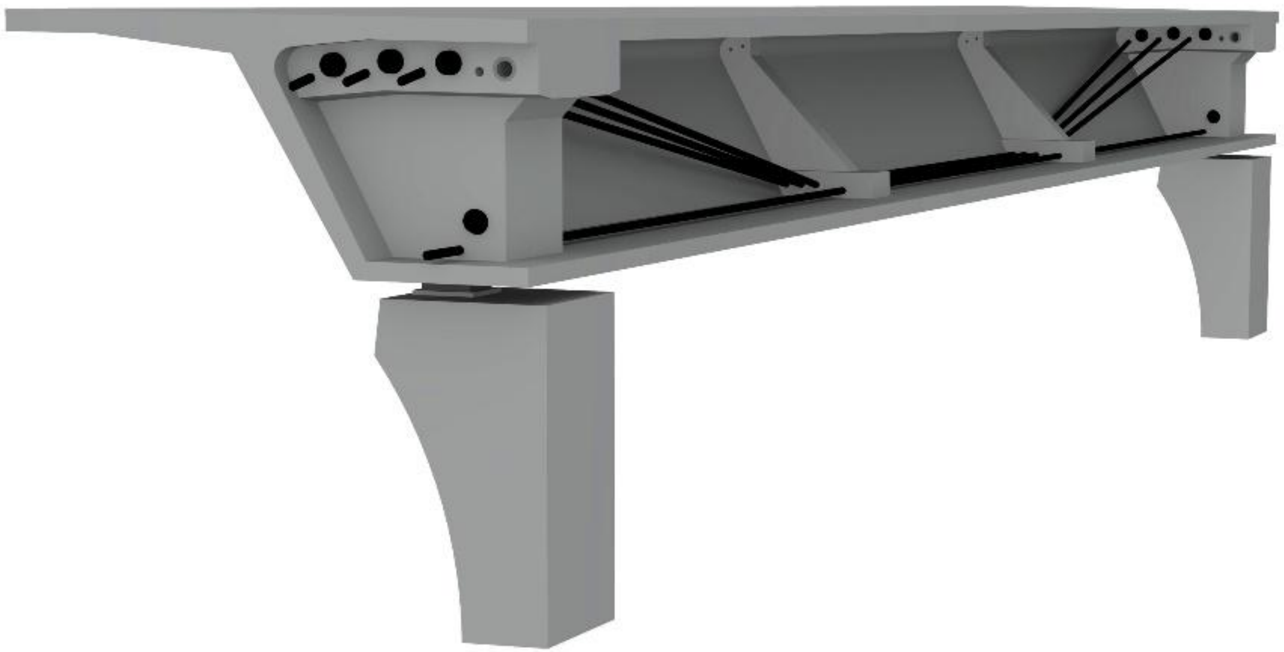
First Segmental Bridge Concept Built in the USA 1953

Griffith Road Crossing of East Koy Creek, New York
Jean Muller International (JMI)

Segmental Construction

Segmental construction is a method in which primary load supporting elements (segments) are post-tensioned together to form simple span and multi-span continuous bridges.

- Concrete
- Predominately box girders
- Top slab matches roadway cross section



Schematic of Span-By-Span Segmental Made Continuous
Hardesty & Hanover (H&H)

Segmental Bridge Categories

Span-by-Span

- Entire span of precast segments is erected on an underslung truss, overhead gantry, or falsework
- Permanent post-tensioning is generally external to the concrete but inside the box girder

Span-by-Span Underslung Gantry

Honolulu Area Rapid Transit (HART)
Kiewit | HNTB | Figg Bridge Engineers

Segmental Bridge Categories

Precast Balanced Cantilever

Segments are lifted into place using ground- or water-based cranes, or even deck mounted lifters at the end of each cantilever

Segments can be delivered from below or over previously cast spans by segment haulers

Precast Balanced Cantilever Using a Deck Mounted Crane

Tukwila Line Over I-5, WA | Sound Transit | PCL Construction | International Bridge Technology (IBT)

Segmental Bridge Categories

Cast-in-Place Balanced Cantilever

- Segments are progressively cast in their final position, cantilevering on alternating sides of a central pier
- A form traveler is used at the end of each cantilever for setting rebar and forming the geometry of the concrete

CIP Balanced Cantilever Construction

Memorial Causeway Bridge Over the Intracoastal Waterway – Clearwater FL | Florida DOT | PCL Construction | HDR

Segmental Bridge Categories

Cable-Stayed

- A bridge in which the superstructure is supported by inclined cables extending from a pylon above the deck
- Precast or cast-in-place concrete segments are constructed in balanced manner from a central pylon
- Segments are then supported by inclined stay cables

Harped Cable-Stayed Configuration

Veterans Memorial Bridge - Bridge City & Port Arthur TX
Texas DOT | Williams Brothers | Figg & Muller Engineers

Segment Types

Precast

Fabricated in a yard using either the short-line or long-line method

Short Line: each segment is cast next to the previously cast segment in a special adjustable casting machine

Long Line: Formwork matching the shape of the soffit is erected on the ground. A traveling form for the webs and deck is moved along the soffit form for the casting of each segment

Short Line Casting Yard with over 75 Casting Machines

Bang Na Expressway – Bangkok Thailand | Expressway Authority of Thailand (EXAT) | Bilfinger Berger (BBCD) | Jean Muller International (JMI)

Segment Types

Cast-in-Place

- Fabricated one segment at a time from alternating sides of a central pier
- Segments are formed and cast from a form traveler
- Post-tensioning tendons are stressed for each segment, enabling advancement of the traveler to the next segment location

Twin Wall Pier CIP Balanced Cantilever

US 54 Bridge – Logan, NM | New Mexico DOT | Malcolm International | Jacobs, McNary Bergeron & Johannesen

Construction Engineering

- Separate topic not covered explicitly in the design manual
- Considerations
  - Integrated shop drawings
  - Casting yard design and layout
  - Geometry control
  - Erection equipment
  - Temporary works
  - Specialty equipment, i.e., erection gantries, jacking frames, segment lifters, shoring towers, etc.
  - Repairs and corrections

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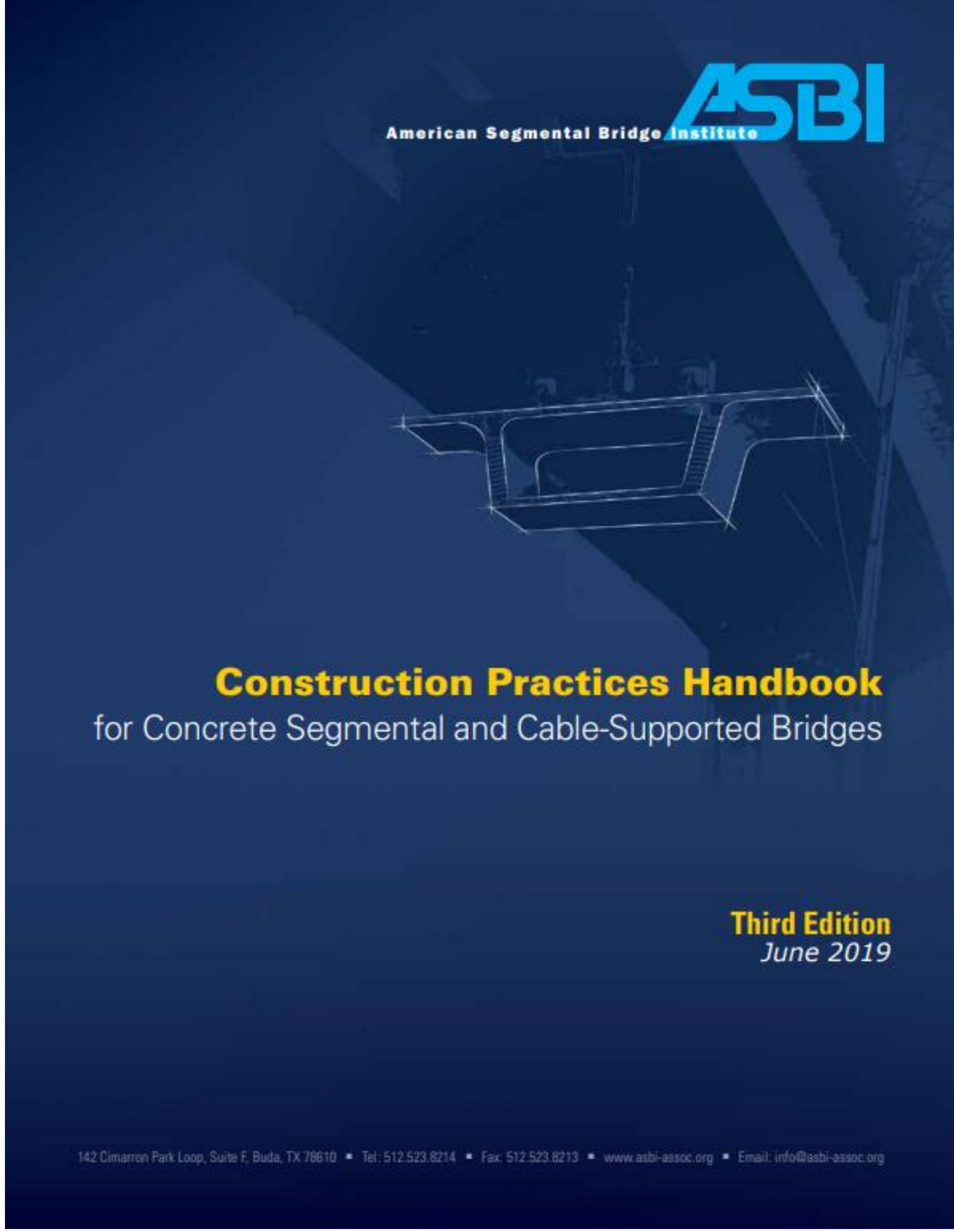


Sample Projects

- A large sample of segmental projects is provided
- Projects are categorized by span lengths, terrain type, and construction methods to provide examples where segmental bridge construction has provided excellent solutions

Lee Roy Selmon Crosstown Expressway

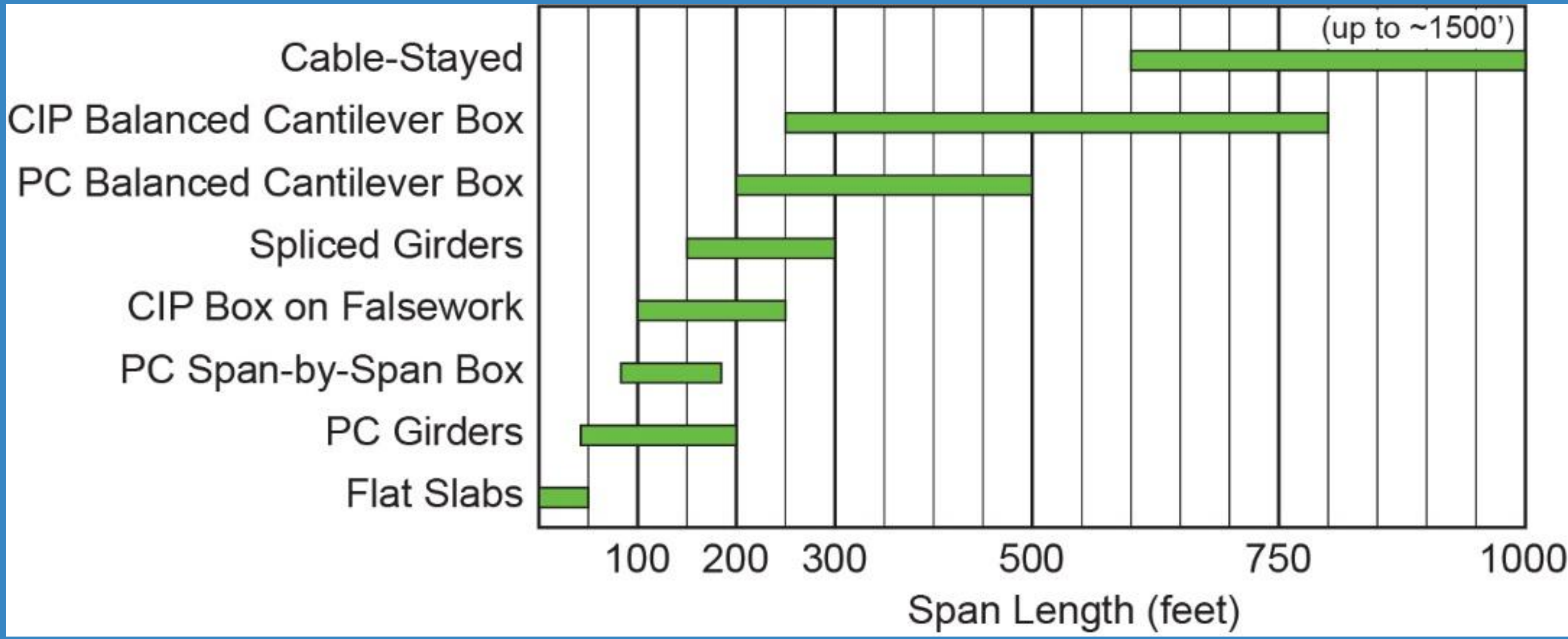
Tampa, FL | Tampa Hillsborough Expressway Authority
PCL Construction | Figg Bridge Engineers

Considerations for Segmental Bridges

Identify bridge type and construction method

Consider the following

- Site constraints
- Span lengths
- Aesthetics
- Cost
- Schedule



A major advantage of segmental bridge construction is that it provides a highly customizable solution.

Economic Factors

Site Constraints

- Advantages
  - Wide deck to narrow pier creates space when building within existing roadway medians
  - Easily adapted to a wide range of alignments and geometry, including tight horizontal curves
  - Can be constructed in tight urban environments including the use of top-down construction

Otay River Bridge – San Diego County, CA | California Transportation Ventures | Otay River Constructors (Washington Group/Fluor) | SYSTRA IBT

Economic Factors

Project Size

- Segmental bridges typically include significant mobilization and demobilization costs with project specific equipment
- Segmental bridge type should be matched with average span length, viaduct length, number of piers, etc.

Spans	Type
150’	Span-by-span
200’ – 225’	Precast B/C
300’ – 800’	CIP B/C
200’ – 2500’	Extradosed / Cable-Stayed

Bridge Asset Management

Design for service life is approached by utilizing individual strategies (Chapter 8)

Owner's Manuals developed by the designer and builder are recommended

- Maintenance Plan
- Items of Special Emphasis
- Load Ratings
- Documentation of As-Built Conditions

San Francisco-Oakland Bay Bridge – Oakland Bay, CA | Caltrans | Kiewit, Flatiron, Manson (KFM) | TYLin, Moffat and Nichols JV

Materials

- Usually 5.5 to 8.0 ksi for post-tensioned elements
- High Performance Concrete
  - Performance Characteristics
  - Structural Design Characteristics
- Ultra High Performance Concrete
  - Include strengths > 17.5 ksi
  - Water-to-cement < 0.25

Monterrey Transit Line 2 – Monterrey, MX | MTA (Monterrey Transit Authority) | Garce Ponce Construction, VSL | Weidlinger Associates

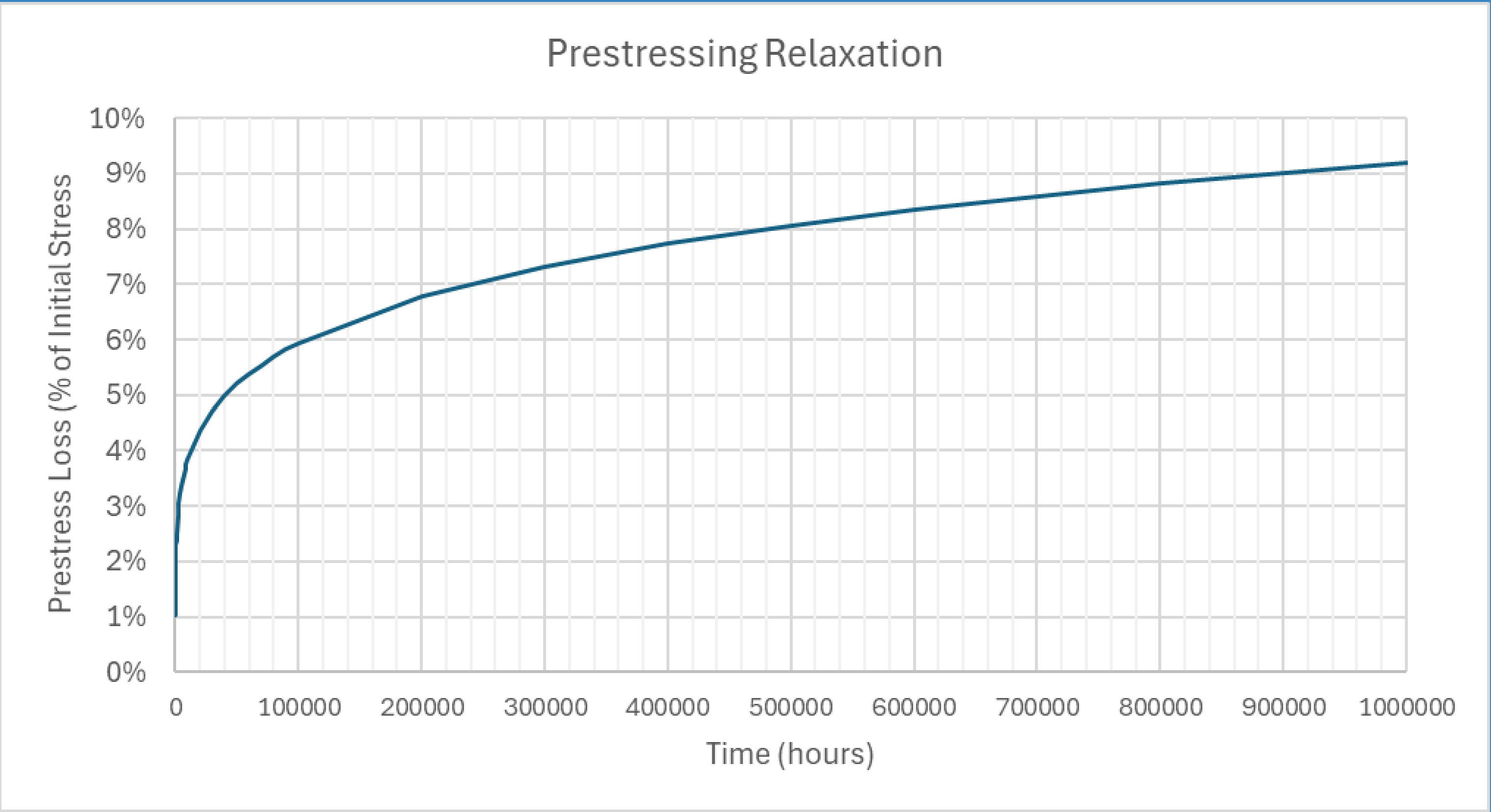
Time-Dependent Effects

- Creep & Shrinkage are important considerations
- For continuous spans, this will cause force redistribution
- For bridges built in balanced cantilever, these effects can have a great effect on flexure after continuity is made
- Future tendon provisions are required in part to address this when needed

John T. Collinson Bridge – Escambia Bay, FL | CSX Railroad
Figg & Muller Engineers | LoBuono Armstrong (CE)

Time-Dependent Effects in Post-Tensioning

- Post-tensioning experiences relaxation over time
  - This relaxation results in appreciable force loss in the tendons
- Post-tensioning loses force thru the shrinkage of concrete (also shortens the tendon)
- Post-tensioning also experiences elastic shortening similar to pre-tensioned concrete beam design



Typical Prestressing Steel Relaxation (fib 2010)

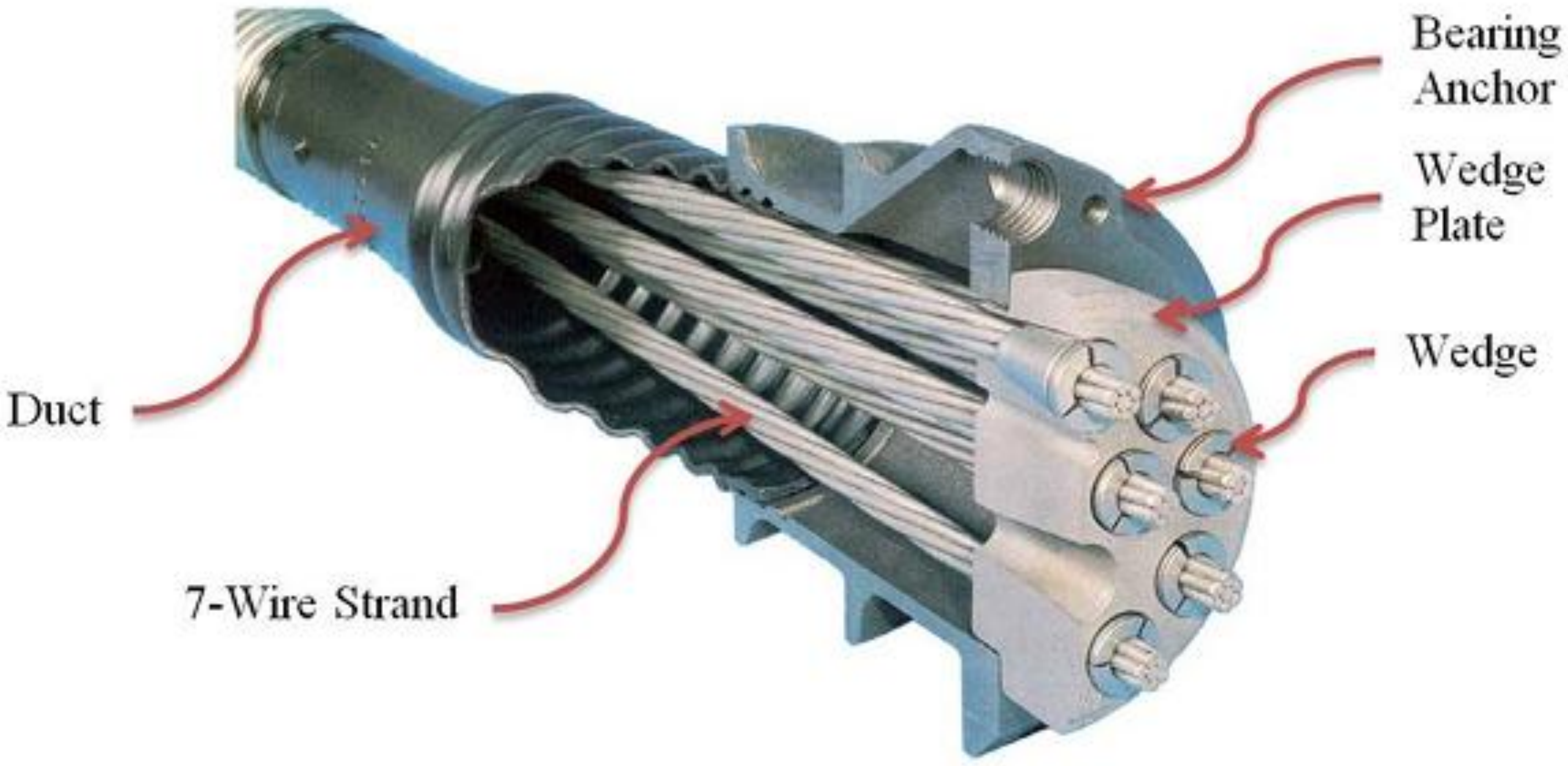
Immediate Losses in Post-Tensioning Force

- Anchor Set
  - Loss is caused by the movement of the tendon during the seating of the wedges or the anchorage gripping device
- Wobble
  - Loss caused by unintentional slight deviations in duct layout
- Friction
  - Loss resulting from the friction between the internal curved prestressing tendons and the duct wall due to design plan physical deviations

Manhattan West Deck Cover | Brookfield | Rizanni de Eccher, USA | McNary Bergeron & Johannesen

Post-Tensioning

- Duct
- Trumpet
- Bearing Anchor
- Wedge Plate
- Wedge
- 7-wire Strand



Multi-Plane Anchorage System (VSL)


Typical 7-Wire Post-Tensioning Strand

Grout

- Cementitious material
  - Occupies space between duct and strand
  - Provides alkaline environment for the strands
  - Establishes bond between the strand and surrounding concrete
- Alternate materials, such as ‘flexible filler’ are being introduced in some states including Florida

Grouting of Post-Tensioning Tendons

Aesthetics

- Often specified in RFP / Scope
- Segmental bridges are aesthetic by their nature
- Additional enhancements may be requested by the owner
  - Structural shapes
  - Relief surfaces
  - Curved surfaces
  - Medallions
  - Lighting

St. Anthony Falls Bridge (I-35W) – Minneapolis MN | Minnesota DOT | Flatiron-Manson Joint Venture | Figg Bridge Engineers

Span Layouts

- Pier placement is a key consideration at early design stages
- Shorter spans are optimal for situations where foundation construction is least costly
- The creation of a cost curve of superstructure + substructure for various span lengths is a good approach to optimization

Ernest F. Lyons Bridge – A1A over Indian River Intracoastal - Stuart FL | Florida DOT | PCL Civil Constructors | Parsons Transportation Group

Deep Foundations

- Single drilled shaft
  - Usually large diameter
  - Eliminates the pile cap
- Drilled Shafts
  - High capacity
  - Larger pile cap required
- Concrete Piles
  - Generally economical
  - Good when bearing strata < 100’
- Steel H-Piles / Steel Pipe Piles

Vancouver Millennium Line – British Columbia | Sky Train | SAR JV | Jean Muller International (JMI)

Large diameter (10-ft.) cased shaft production – drilled and cast in a single day

Pier Substructures

Column shape largely driven by structural and aesthetic requirements

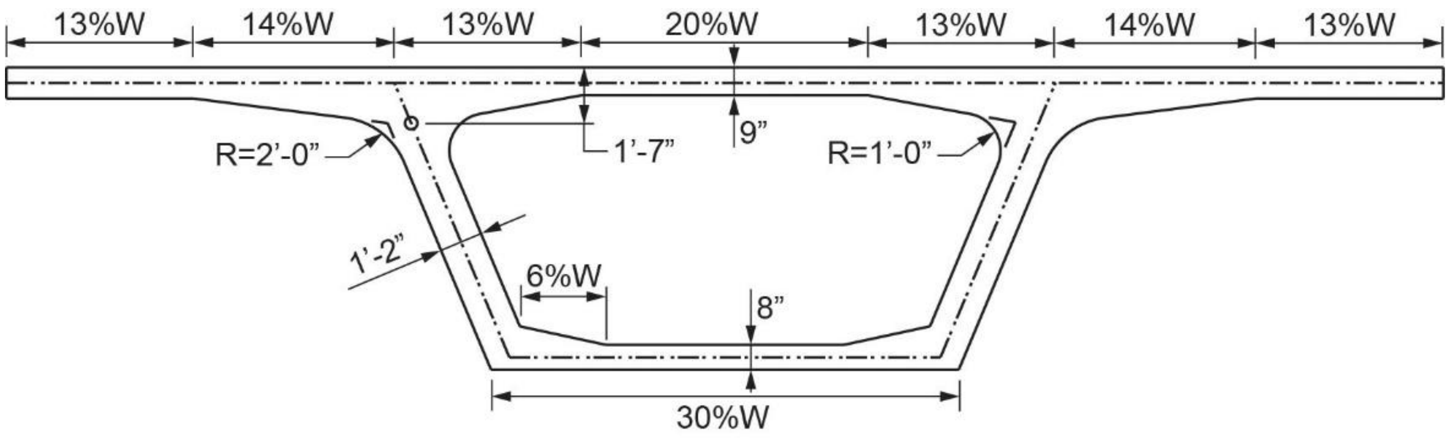
Hollow columns may offer significant concrete quantity savings for projects with taller piers.

Twin wall piers are more flexible in longer spans and reduce bending moments due to long-term creep & shrinkage effects

Tukwila Line Over I-5, WA | Sound Transit | PCL Construction | International Bridge Technology (IBT)

Superstructure Proportioning

- Roadway width is the initial factor to consider
- Two critical geometric dimensions result
  - Distance between web walls
  - Length of cantilever overhangs
- A good rule of thumb is to proportion the overhangs at 40 – 45% of the interior span between web walls



Typical Segment Proportions

Superstructure Proportioning

- Constant depth structure is generally more economical than variable depth
- Constant depth can typically be used for up to 200’ spans
- Optimal span to depth ratio for constant depth is 20
- Optimal ratio for variable depth is 18 to 20 at piers and 40 to 50 at midspan

Wakota Bridge I-494 – South St. Paul over the Mississippi River | Minnesota DOT | Lunda Construction Co. | HNTB

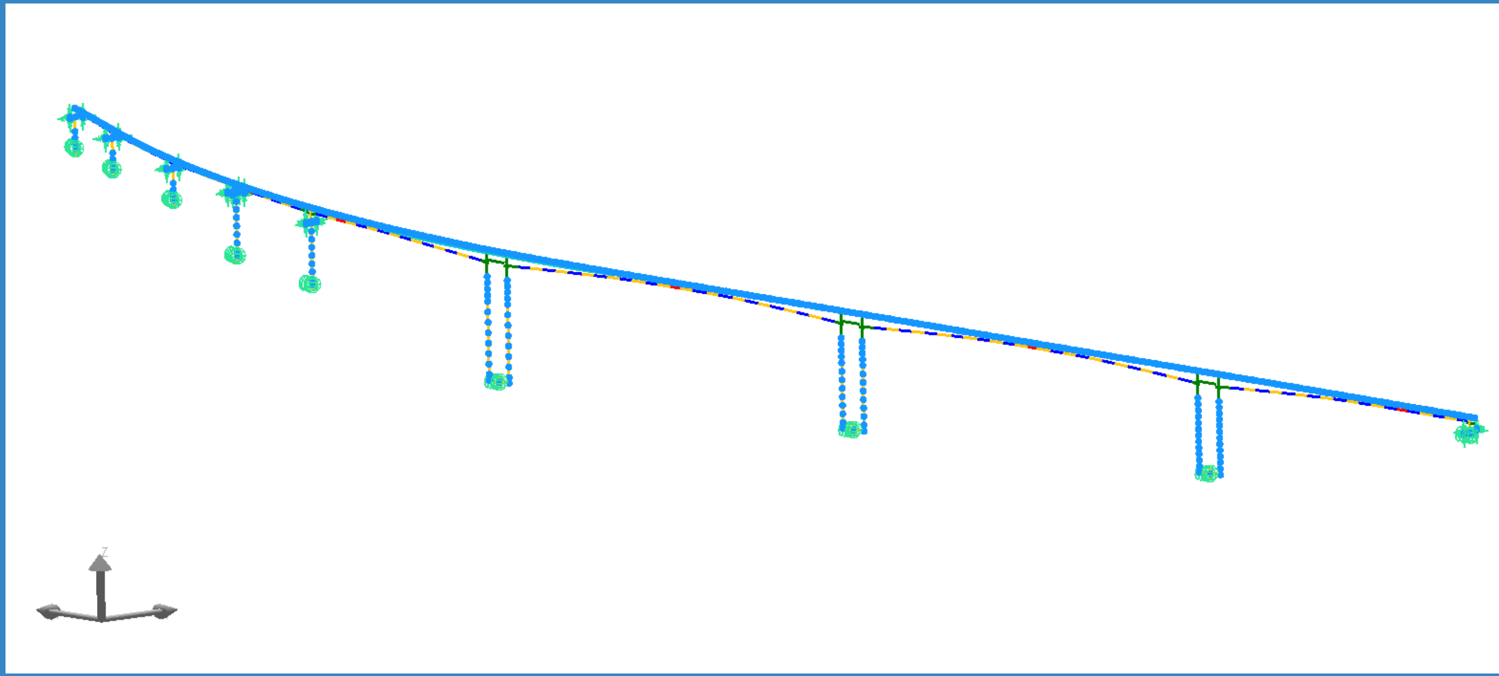
Structural Modelling

Adequate level of detail and accuracy

Remain simple enough to enable efficient iterations

Beam element models are usually sufficient for analyzing most aspects of these bridges

Software must be able to model post-tensioning, losses, and staged construction



Beam Element Model for Segmental Bridge Built in Balanced Cantilever

Post-Tensioning Layouts

- Determined by the construction method chosen
- Tendons can be unbonded or bonded, internal or external
- Design plans will typically specify jacking force; the force applied is also backchecked in the field by measuring strand elongations

Post-Tensioning Layouts

- Bonded Tendons
  - Embedded in concrete and grouted with cementitious grout
  - Grout protects the strands and ensures the strand and concrete strain together
- Unbonded Tendons
  - External to the concrete section, but within the box girder

Interior View of External PT Deviating at Deviator Segment

Preliminary Element Checks

Substructure Checks

Size and number of foundation and column elements are sufficient

Superstructure Flexure checks

Service level stress checks usually govern and sufficient at this stage (there are exceptions)

Superstructure Principal Tension

Ensures the web is of sufficient thickness

Delta Ponds Pedestrian Bridge - Oregon
DOWL | OBEC, Jiri Strasky

Construction Considerations

Means & Methods

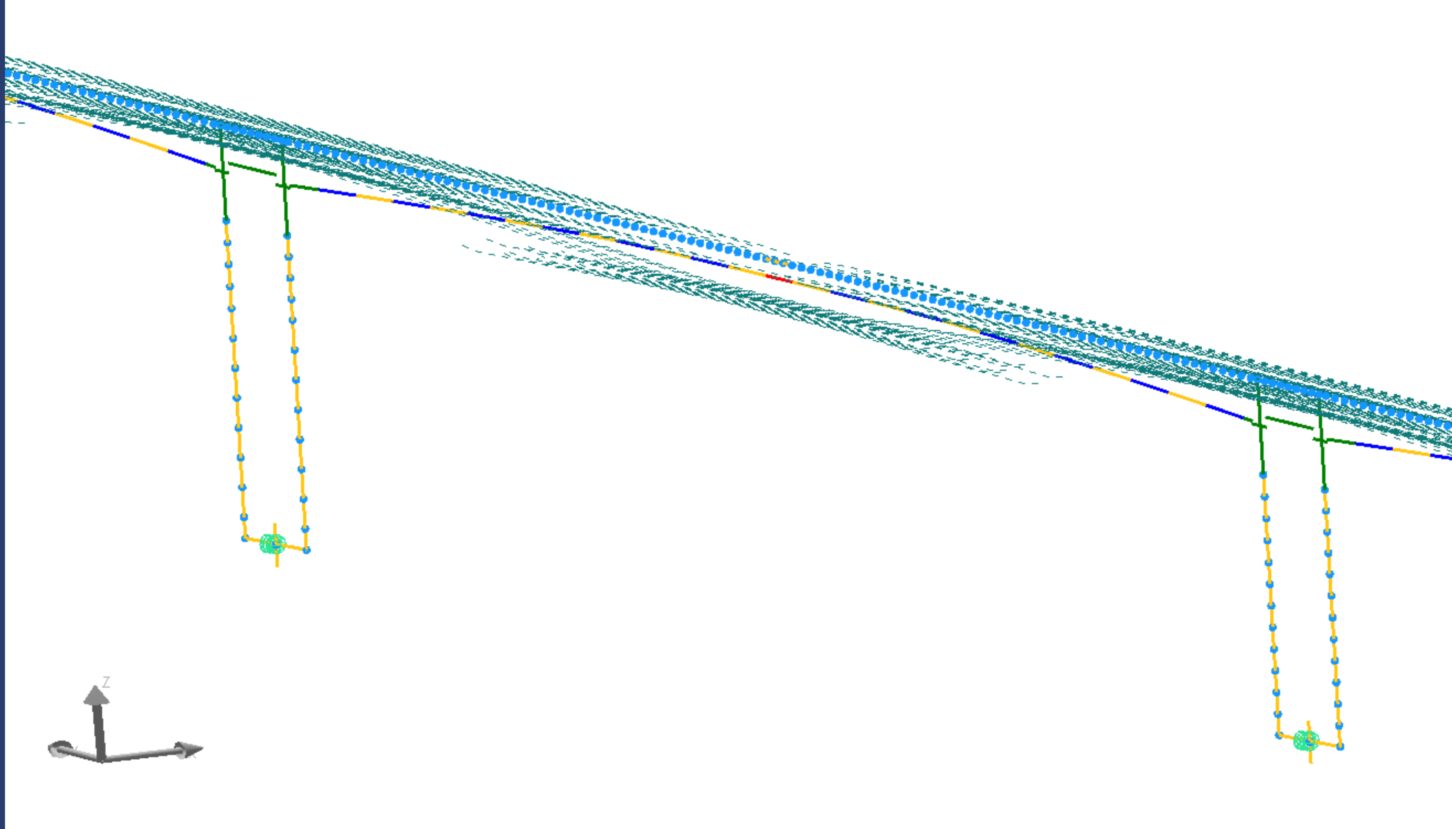
- Form travelers, erection gantries, & ground-based cranes are important considerations
- Critical means & methods must be established in the design criteria and on the preliminary plans
- Closure sequence is important due to secondary load effects on previously erected spans

Vancouver Millennium Line – British Columbia
Sky Train | SAR JV | Jean Muller International (JMI)

Longitudinal Analysis and Design

Structural Modelling

- Stage-by-stage analysis should mimic as closely as possible every step of the construction stages
- PT tendons are fully detailed to capture final losses and jacking forces determined
- Specialized local modelling is sometimes prudent, to include plate models and perhaps brick modelling for special elements



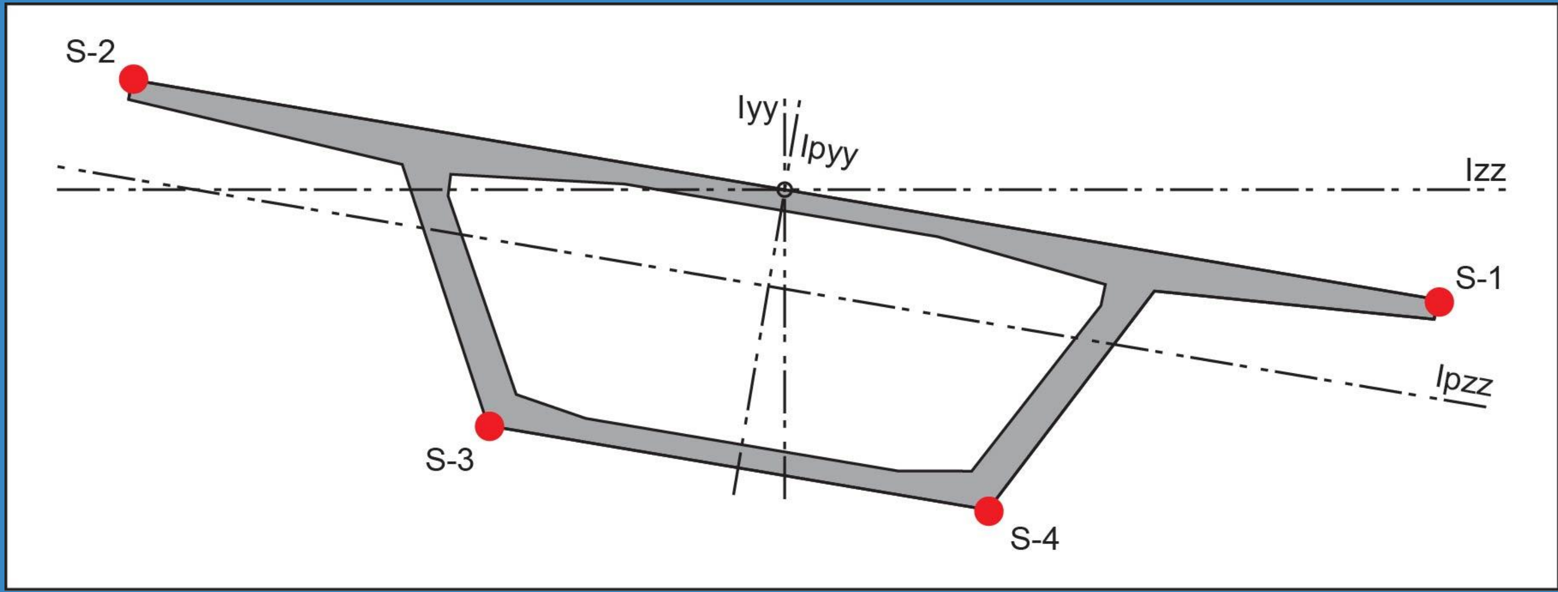
Flexural Design

Service Checks

- In-service and construction checks
- Important to check extreme stress points

Ultimate moment checks

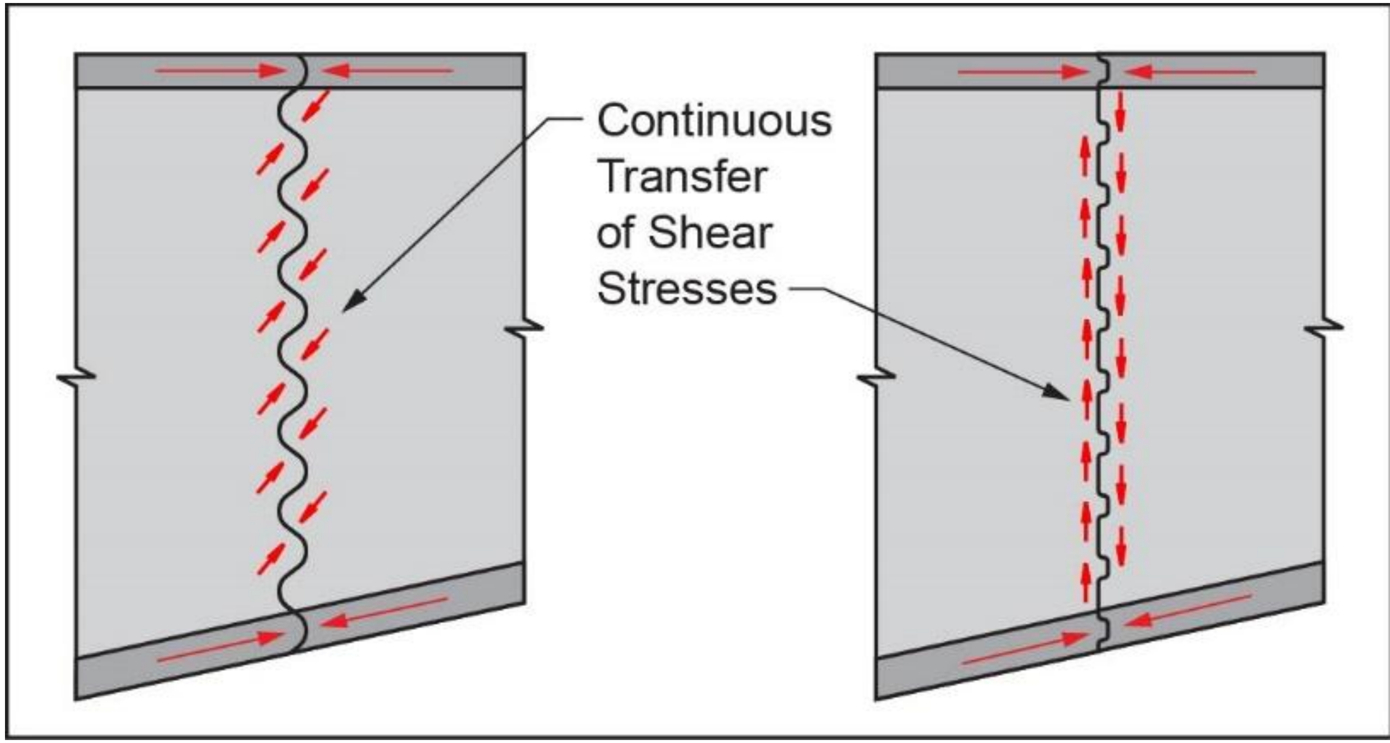
- Flexural strength typically does not govern the design
- AASHTO flexural equations are used
- When needed, strain compatibility may be used when the approximate methods are inadequate



Stress Recovery Points shown on a Rotated Cross-Section for Superelevation

Shear & Torsion Design

- Shear is checked in service through principal tension in addition to the typical strength limit state
- Concrete box girders are very efficient at carrying torsion
- Torsion is combined with the primary source of shear from vertical loads
- When harped external tendons are used, shear effects can be offset by the vertical component of the shear force

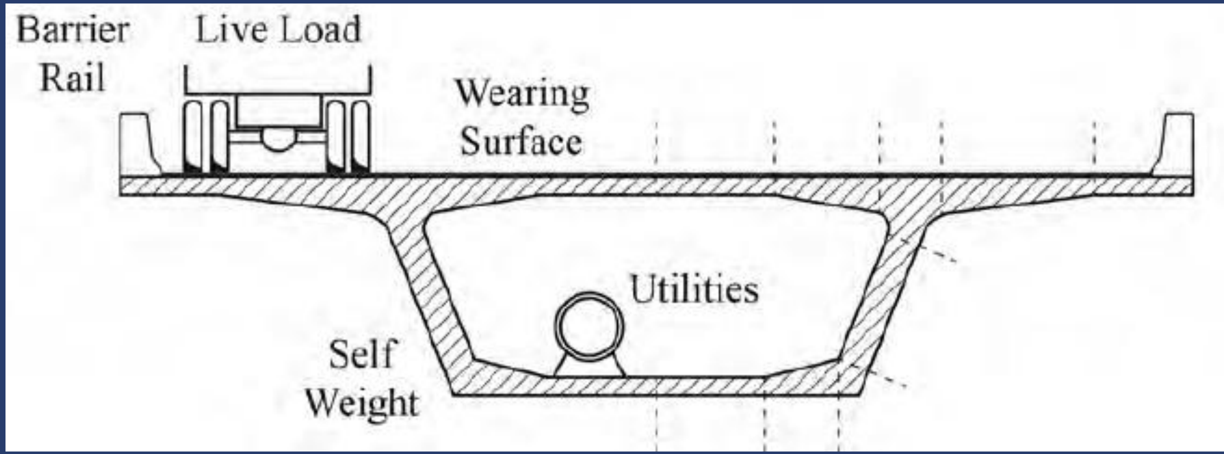


Shear Transfer with Shear Keys at Segment Joints through Bearing and Friction

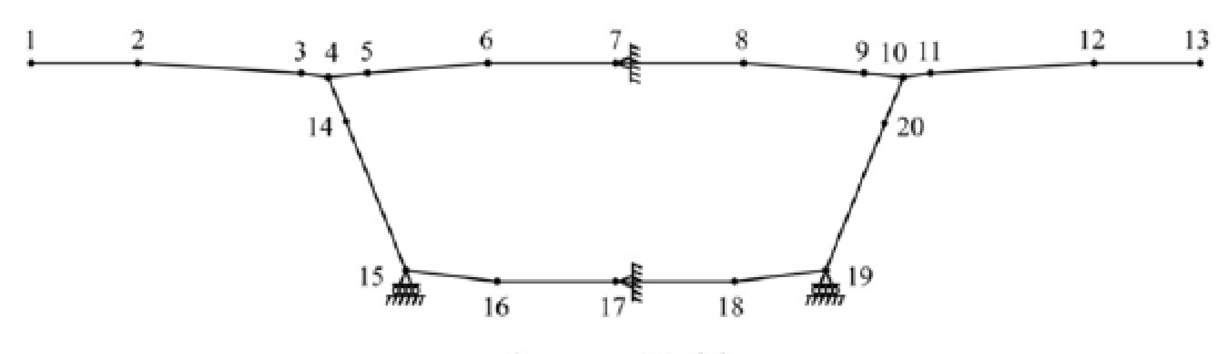
Transverse Analysis and Design

Typical Segment Analysis

- Model cross-section as frame
- Evaluate transverse bending moments
- Permanent & Live loads
  - Traditional methods use surface charts to distribute loads to the frame
  - Modern techniques use plate models to determine live load distribution to the box



External Loads Applied to a Single Cell Box Girder

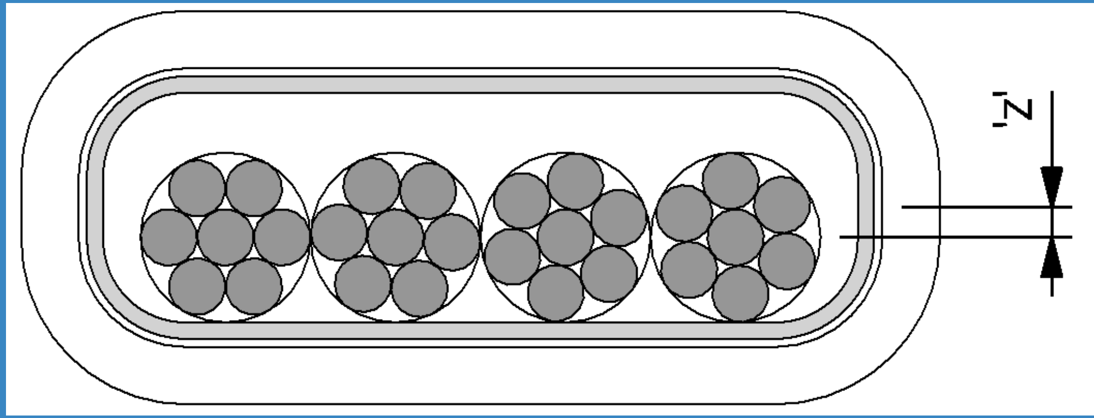


Computer Model

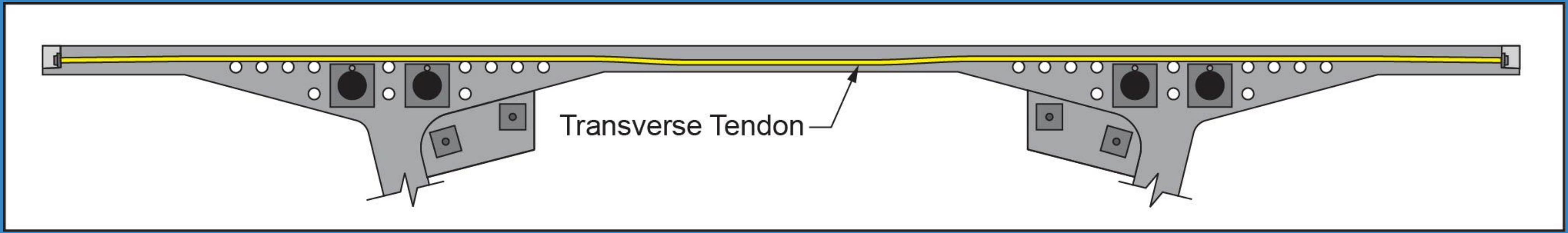
Top Deck Transverse Post-Tensioning

Depending on top slab geometry and purpose, top slabs can be post-tensioned

Post-tensioning provides an additional level of deck protection by compressing in the transverse direction



Offset of Prestressing Strand Within Flat Duct



Construction Considerations

- Segment formwork removal strength
- Lifting strength of precast segments
- Stacking of precast segments
- Temporary supports during erection

Example of Segment Stacking in Storage

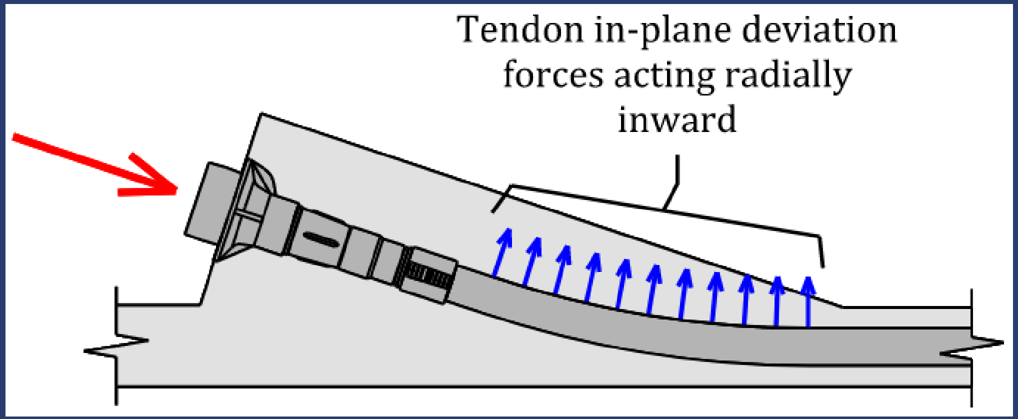
Marc Basnight Bridge – Oregon Inlet NC | North Carolina DOT | PCL Civil Constructors | HDR, Corven Engineering (CE)

Design of Tendon Anchorages and Diaphragms

Anchor Block Design

- Longitudinal edge tension
- Spalling forces
- Bursting forces
- Interface shear friction
- In-plane force effects
- Crack control

Bottom Slab Anchor Block



In-Plane Force Effects Thru the Radial Curve

Anchor Block Design

Detailing Considerations

- Keep enough room in front of the block for the stressing jack and strand
- Perform geometric conflict check with any external tendons in the box girder
- Check reinforcing conflicts with other bottom slab tendons

Double Anchor Block Reinforcing

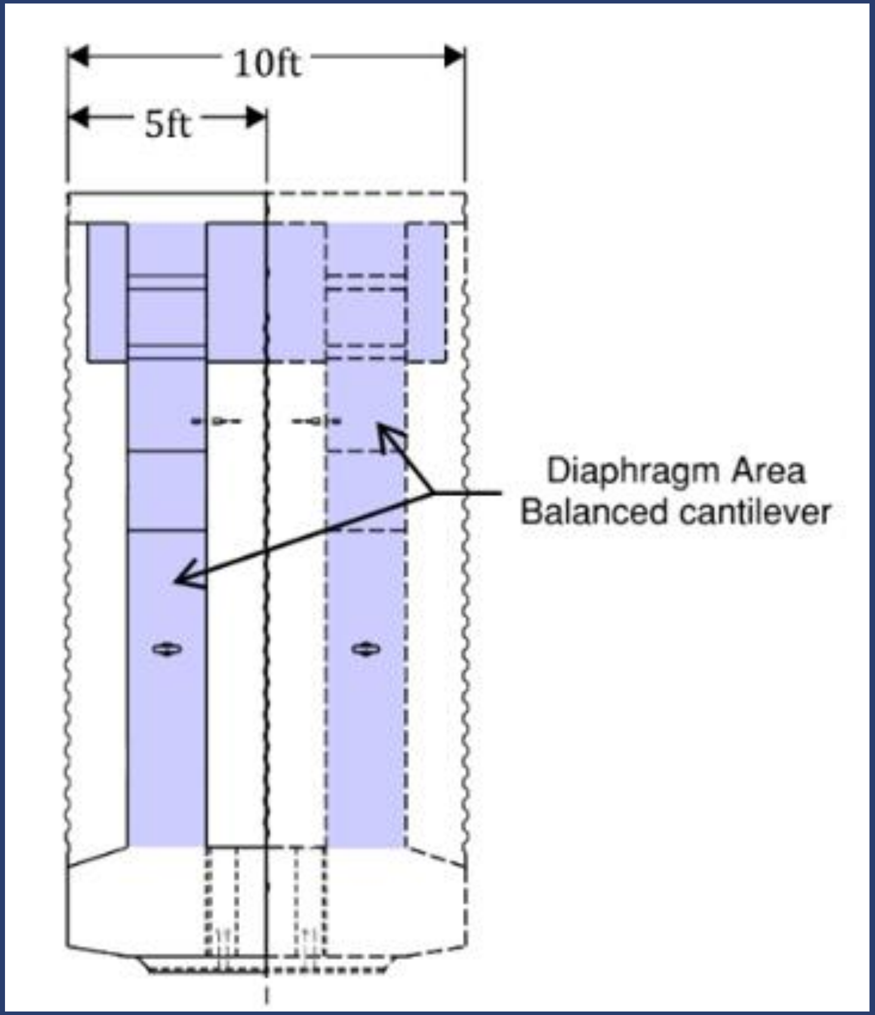
Interior Pier Segments

- General terminology for interior support segments for precast construction.
- May require "split pier segments" for weight restrictions
- Diaphragms transfer load to bearings.
- PT generally acts continuously through segment in final condition.

Interior Pier Segment

Pier Table Design

- Terminology for CIP interior support integral segment
- May have two separate diaphragms for twin wall piers. Requires additional longitudinal strut and tie.
- Transfers forces from the box to the substructure more uniformly versus bearings.



Expansion Joint Segments

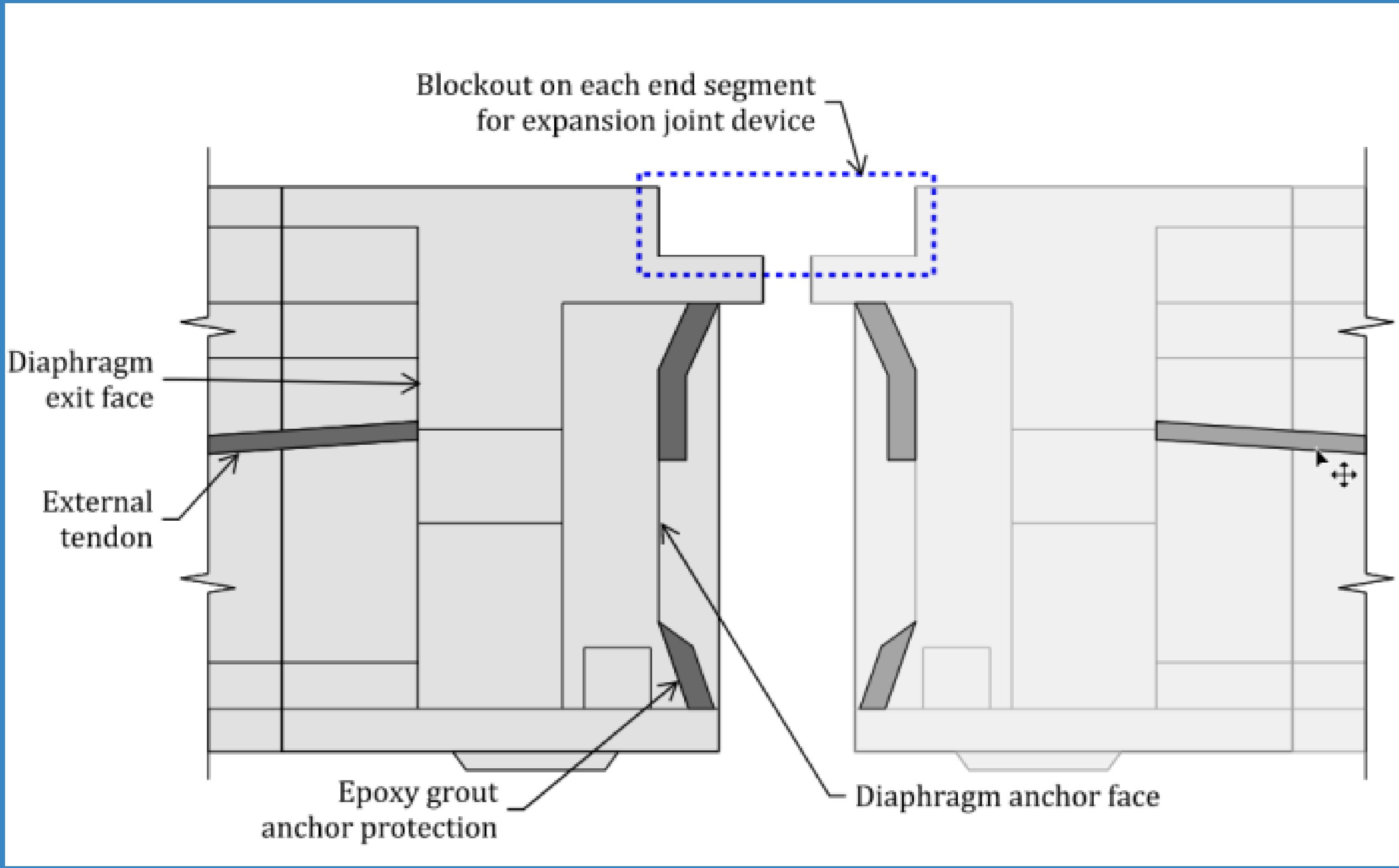
Terminology used for segments at the end of the unit/frame.

Transfers loads from the box to bearings.

Transfers anchorage forces of PT to the girder.

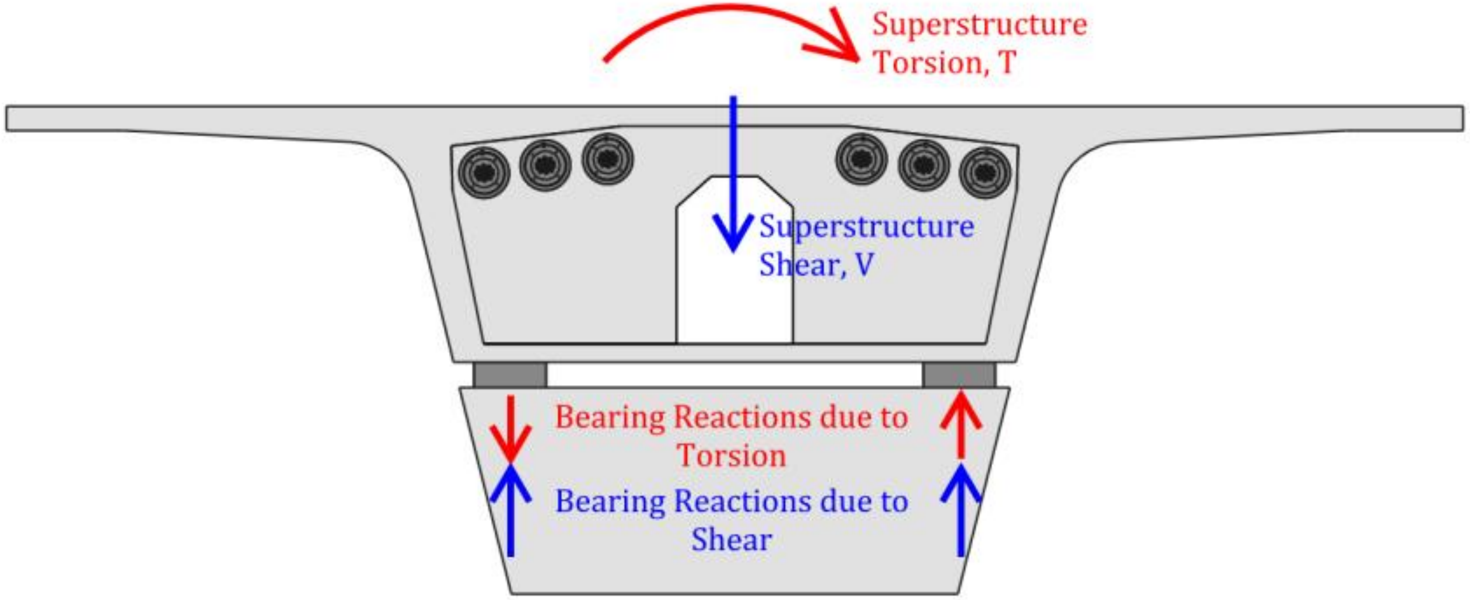
Require block outs for expansion devices.

Requires special considerations for anchorage protection and access.



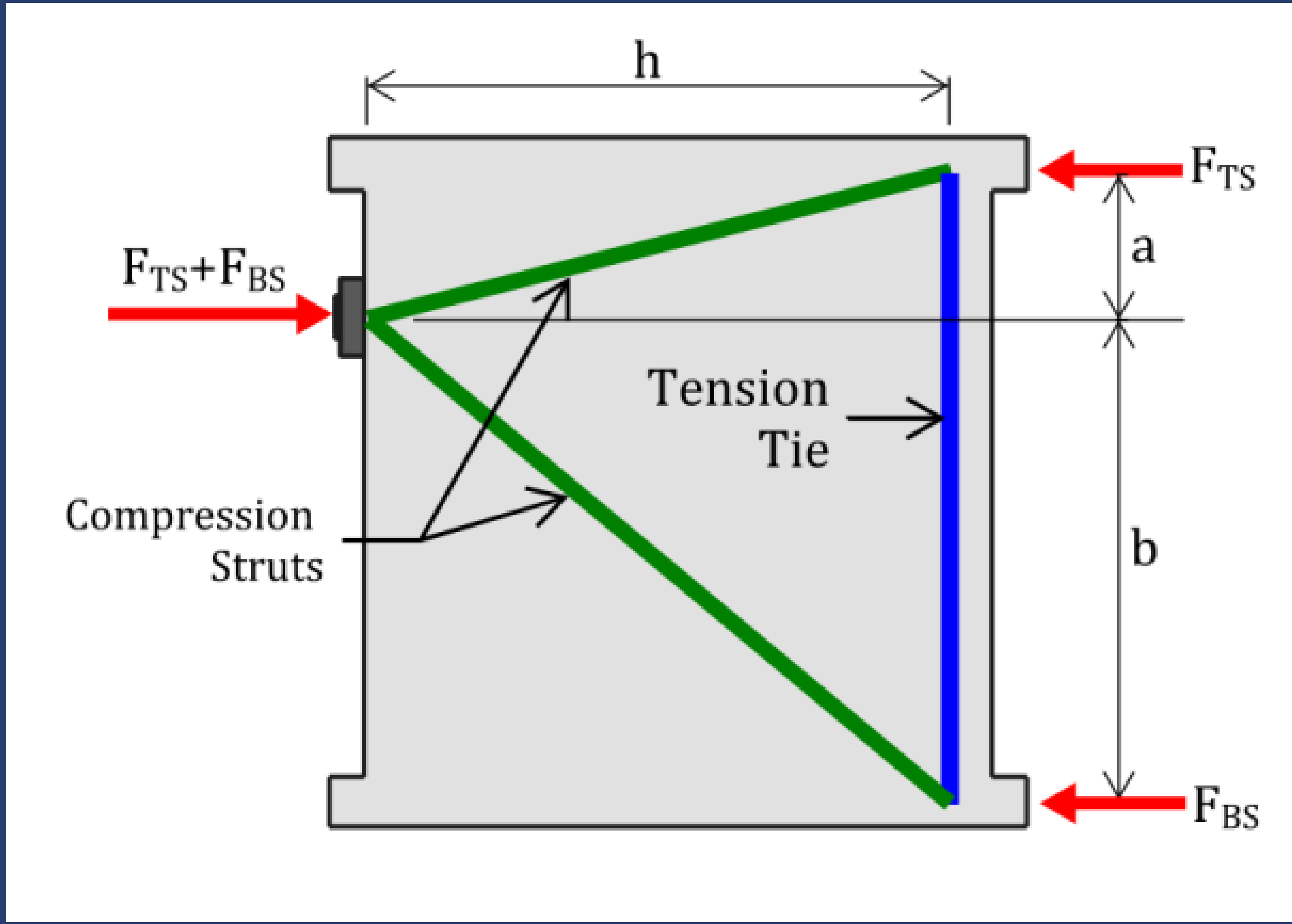
Force Flow within Diaphragms

- Specific design details of diaphragms will be covered in later ASBI Webinars
- Transfer of shear and torsion from box girder to bearings



Force Flow within Diaphragms

- Transfer of PT Anchorage Forces to Box Girder
- Resal Effect
- Lower Web Popout
- Shear Lag Effect



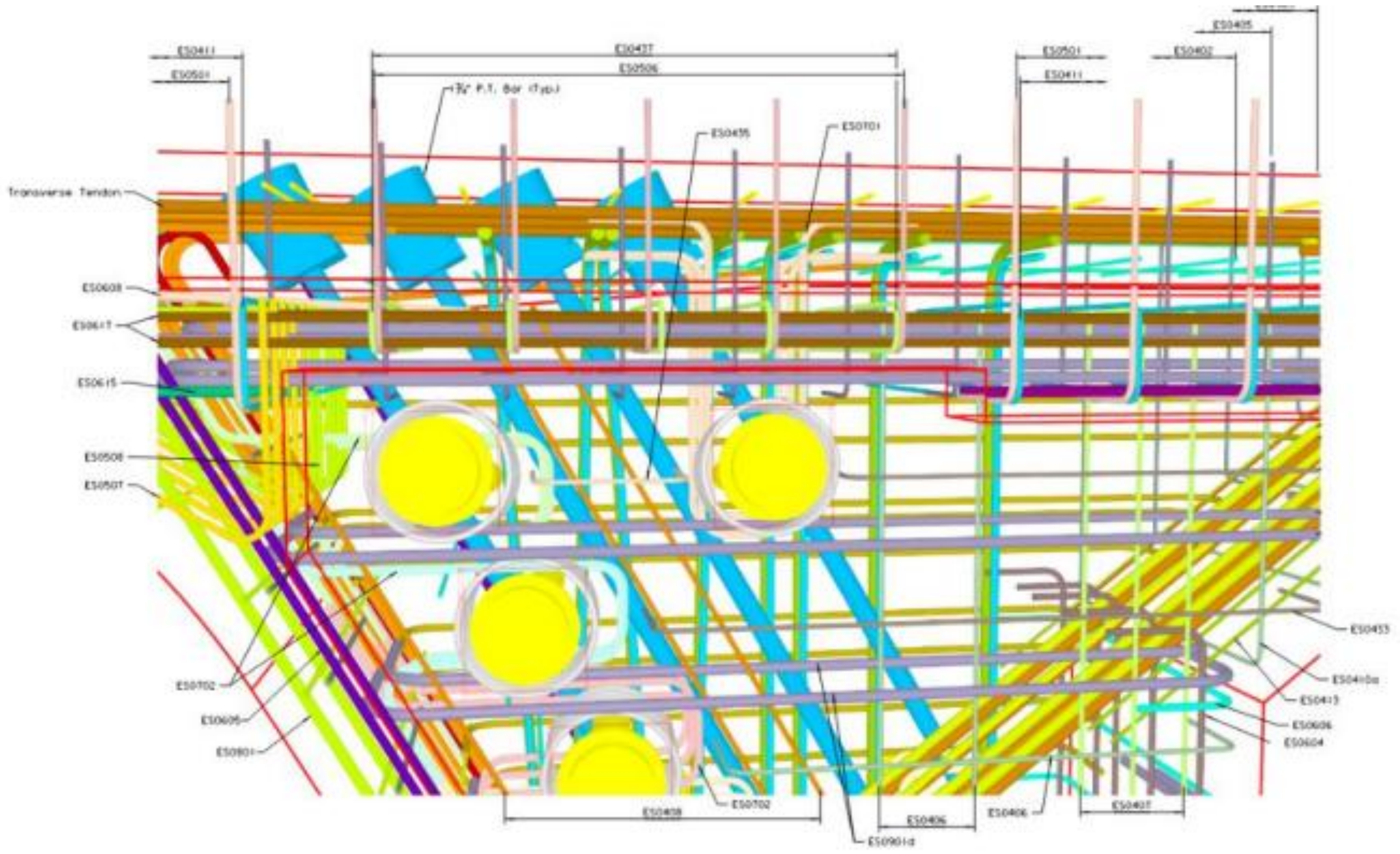
Special Considerations

- Segment weights and size for transport and lifting
- Temporary conditions
  - Pier Segments may temporarily act as Expansion Segments
  - Gantry or other construction loading
  - Temporary supports such as jacks
  - Bearing Replacement

Interior Pier Segment

Diaphragm Congestion

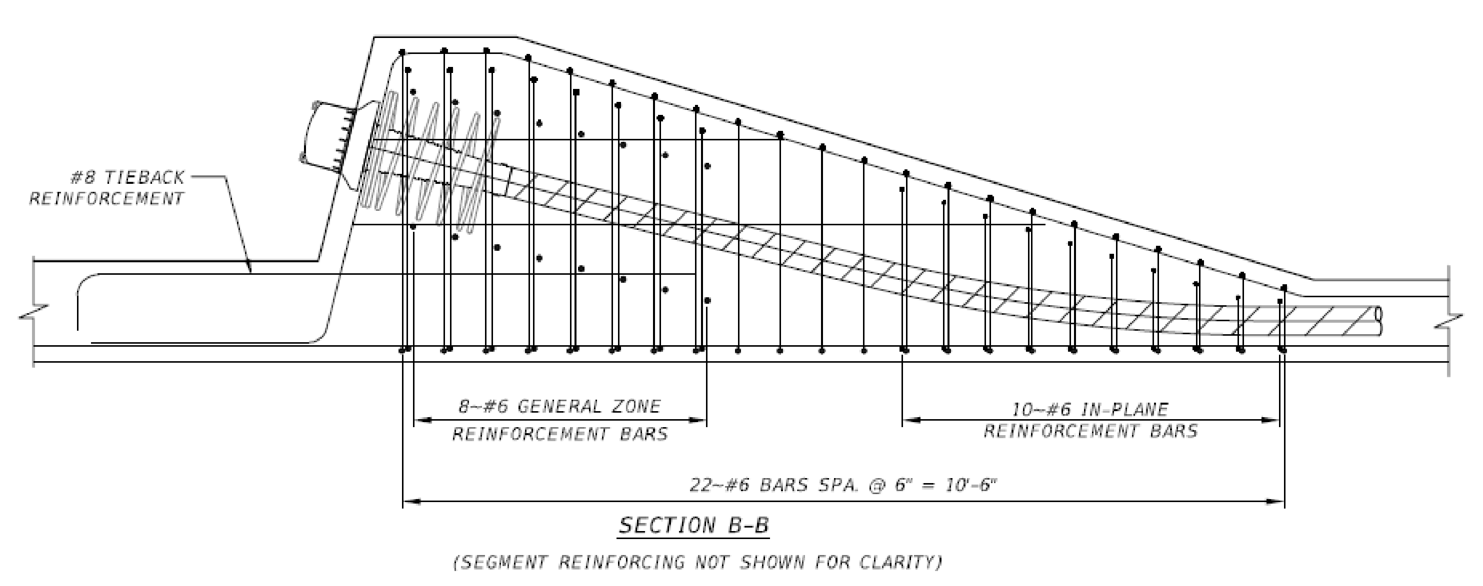
- Diaphragms are generally the most congested areas in Segmental Structures
- Appendix G provides fully worked design examples showing details



Segment Detailing for Post-Tensioning

Segment Detailing

- Provide comprehensive details for the following:
  - typical, pier, expansion joint, and access segments
- Including the following details:
  - Reinforcement
  - Post-tensioning ducts
  - Anchorages
  - Access provisions

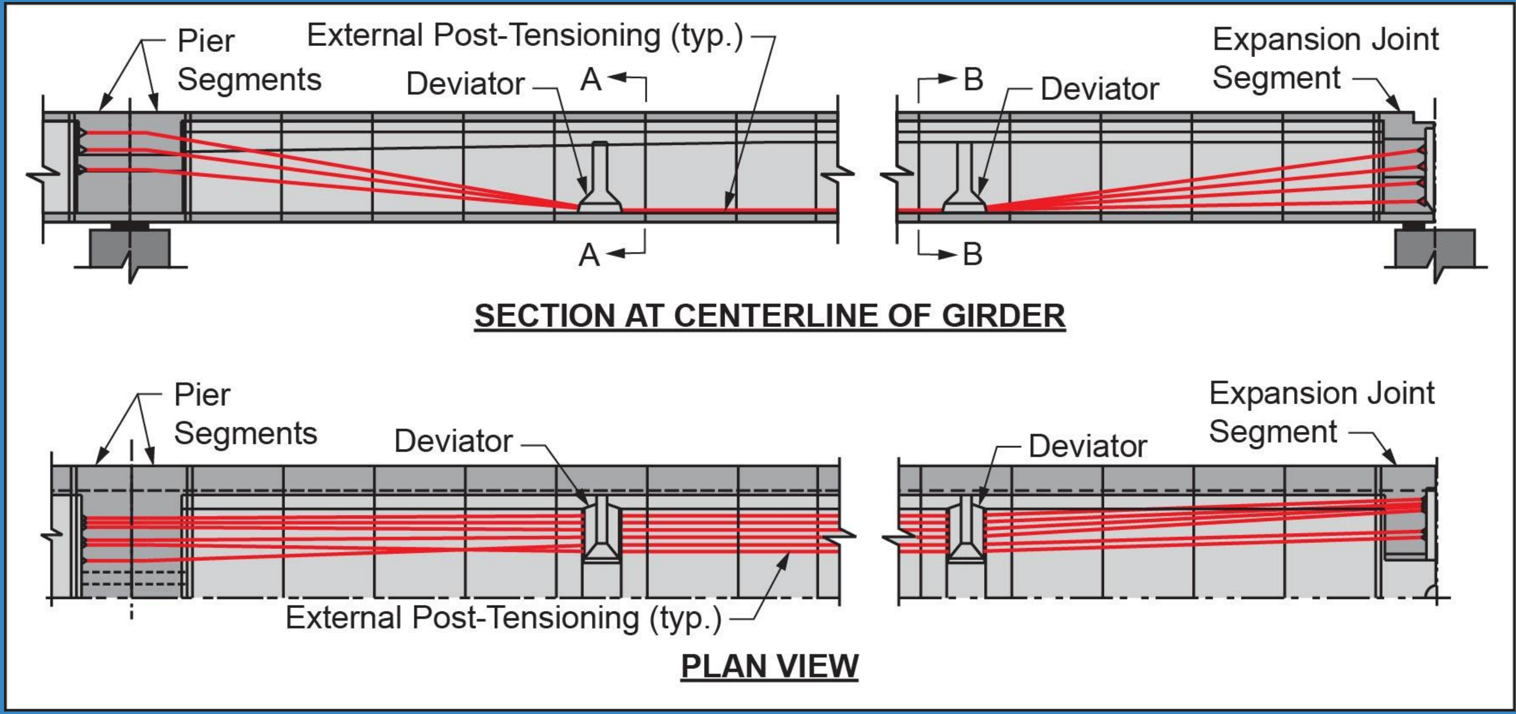


Bottom Slab Continuity Tendon Anchor Blister, Elevation View

Tendon Layouts

Develop detailed layouts for the following:

- Cantilever
- Continuity
- Harped
- Transverse tendons

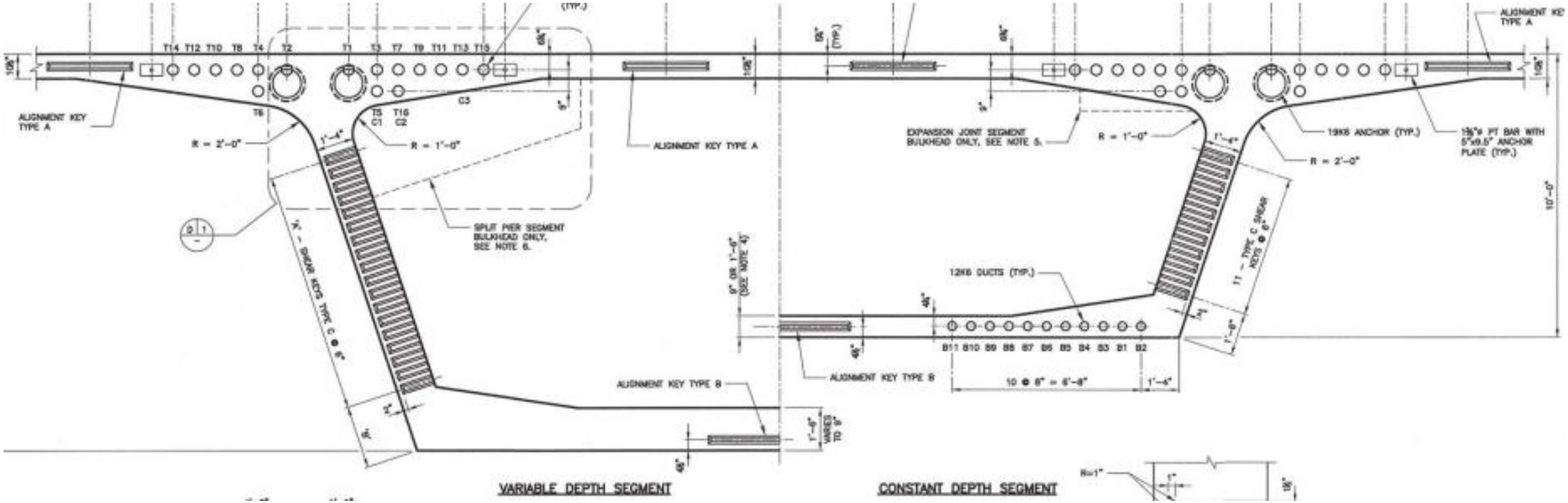


Span-by-Span PT Layout (End Span Elevation and Plan)

Duct Details

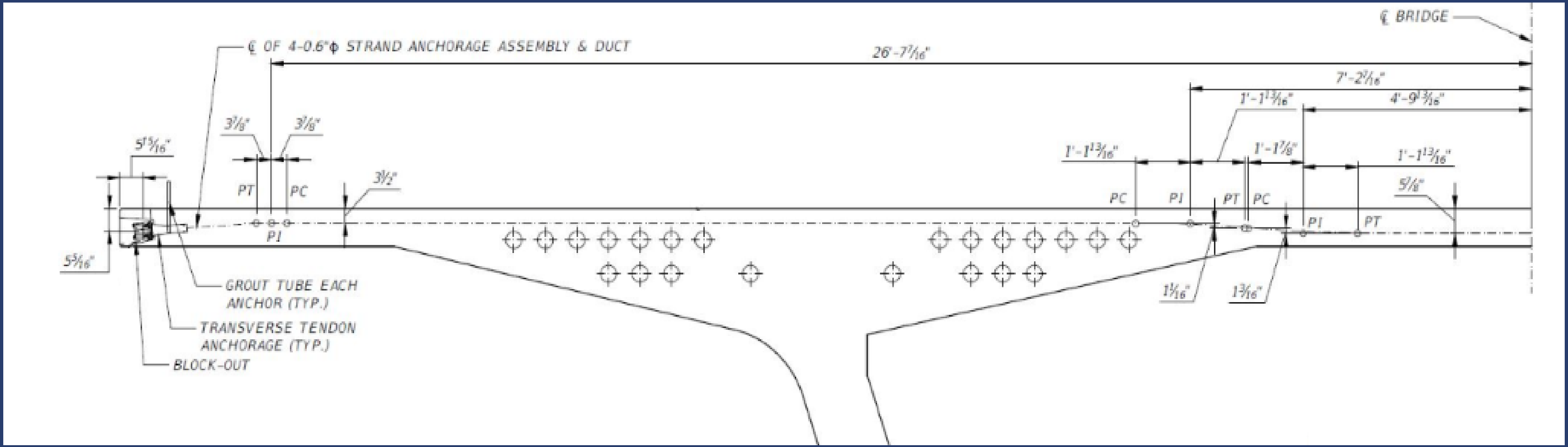
Specify the following:

- duct spacing
- minimum radii
- tangent lengths
- protection details



Transverse Deck Tendons

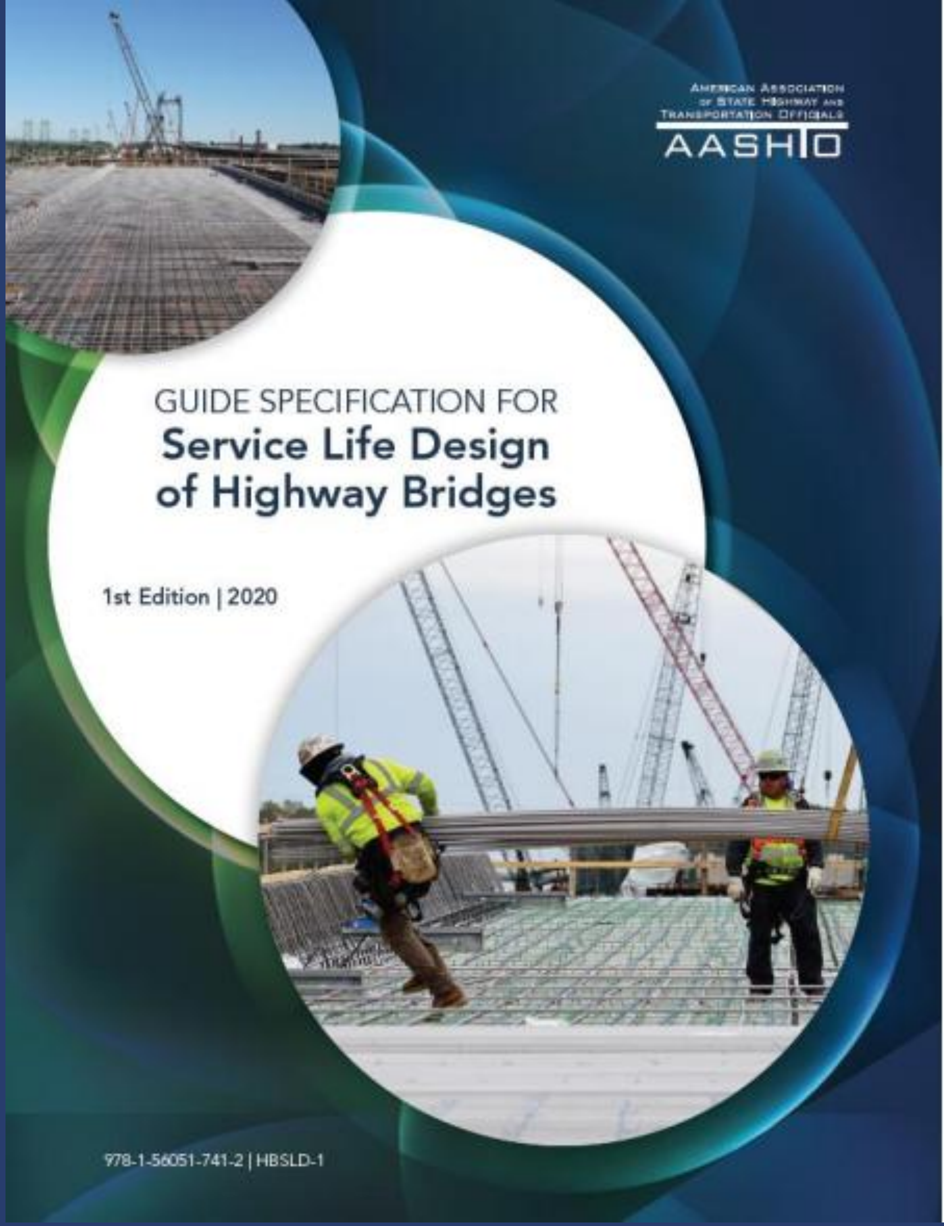
- Detail to remain within the top and bottom mats
- Detail to top of duct to provide a physical point of measurement
- Detail spalling reinforcement between transverse tendon anchors
- Local zone reinforcing is typically for the PT supplier



Design for Durability and Serviceability

Service Life

- Considerations for target service life of structure
- Actual Service Life - "the period of time a bridge remains in operation, without rehabilitation or significant repair, and with only routine maintenance."
- Methods available to define service life in quantitative terms

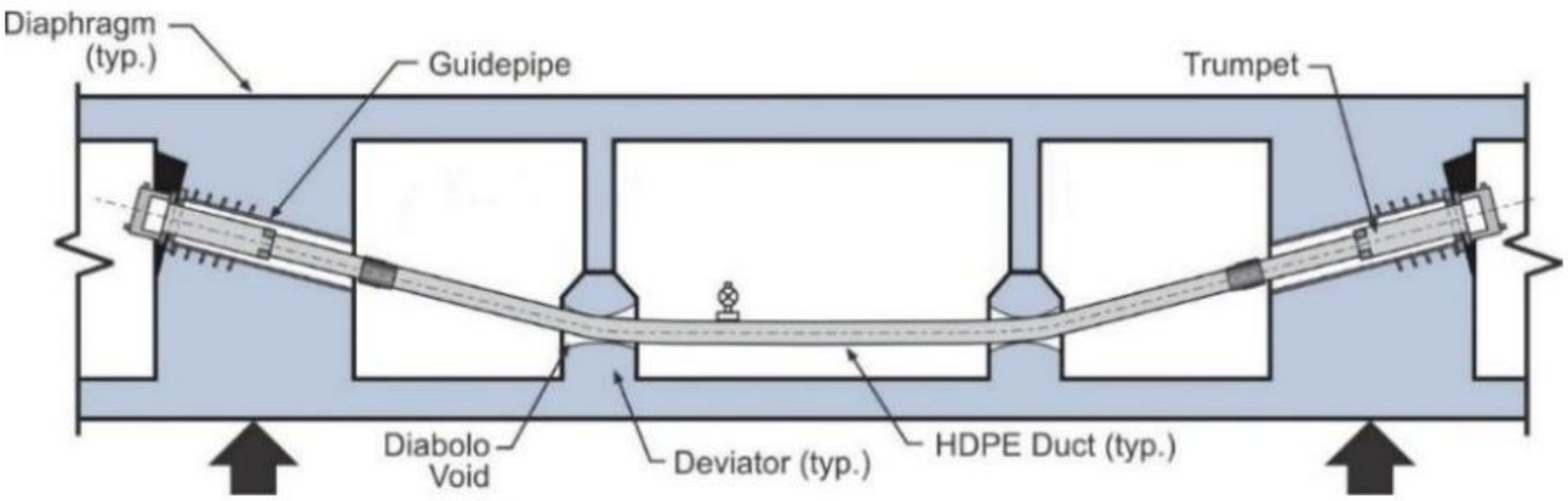


Durability of Post-Tensioning Elements

- PT durability is critical to strength and serviceability of segmental structures
- FHWA Report *Methodology for Risk Assessment of Post-Tensioning Tendons*
- Follow appropriate standards, codes, and guidelines
- Durability Factors and Protection Levels
  - Material and Construction Specifications
  - Tendon Protection Levels
  - Duct Filler Materials and Procedures
  - QC/QA During Construction
  - Personnel training
  - Detailing for Durability and Replacement

Replaceable Grouted External Post-Tensioning

- Unbonded Tendons
- Use of "double envelope details" results in PT not bonded along length of tendon
- Any external tendon is replaceable with localized demolition.



Flexible Filler

- Alternative to cementitious grout corrosion protection
    - Grease or wax
- Can be internal or external, but always unbonded
- Tendons are replaceable
- Guidelines and details presented in FDOT's Structures Design Guidelines

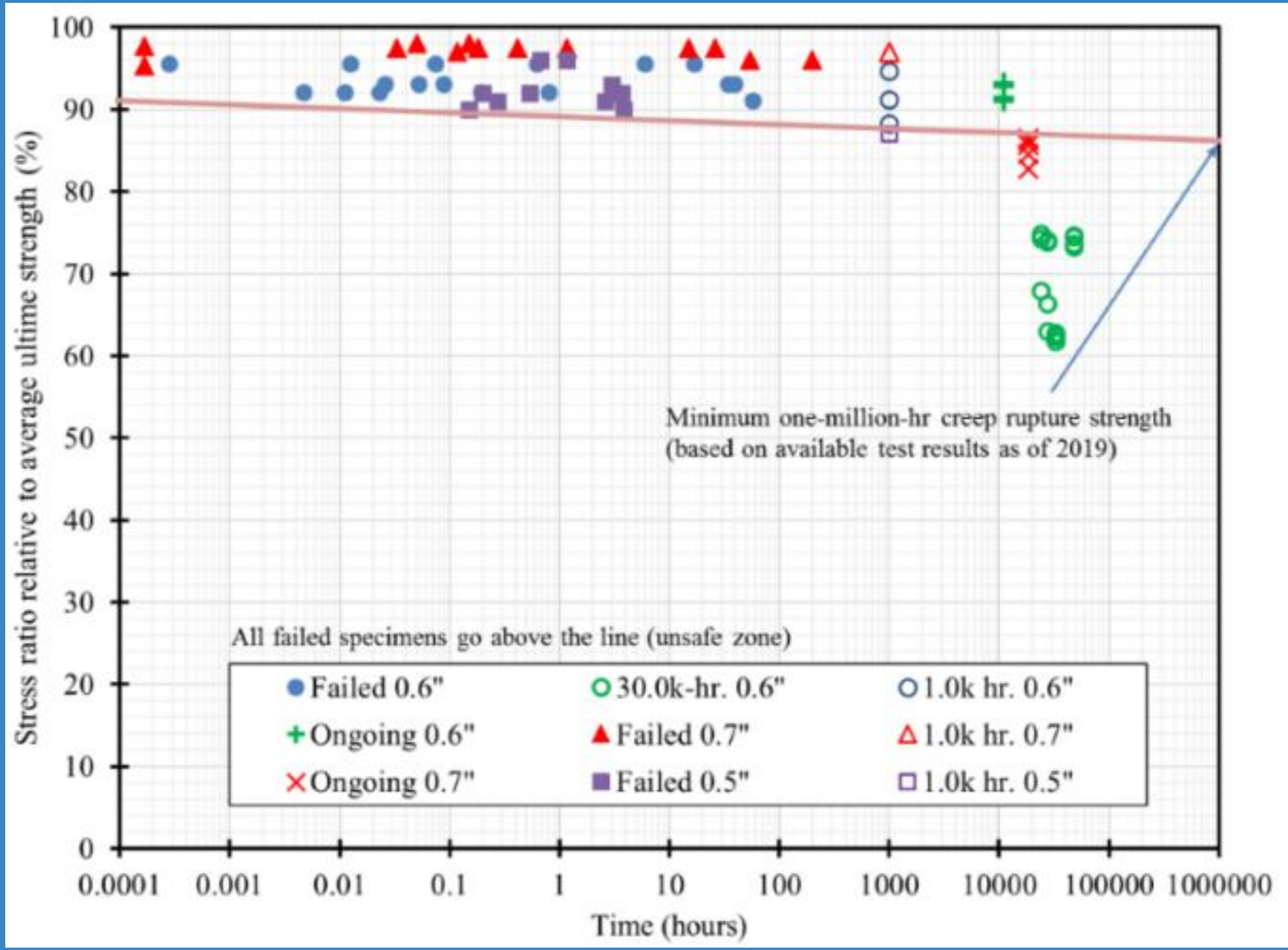
Carbon Fiber

Use as alternative to steel tendons in harsh environments and/or high corrosion potential

Lacks a material yield

Special considerations:

- Steel wedge and sleeve anchorage
- Creep rupture
- Environmental Effects
- Freeze-Thaw Effects
- Fire and Heat Resistance
- Long-Term Performance
- Flexural and Shear Design



UHPC

- Fiber-reinforced cementitious composite
- References provided for design using UHPC
- Has been used for:
    - Segmental Box Girder Deck Rehabilitation
    - Anchor Blocks
    - Precast Structural Segments
    - CIP Segmental Joints
- Potential Benefits for Segmental:
    - Reduce reinforcement in congested areas
    - Material is impervious by nature increasing durability
    - Lighter weight structures for span lengths and pick weights

Summary

- A brief overview of preliminary design considerations has been presented
- Use of the new ASBI Bridge Design Manual has been introduced in conjunction with the various stages of design

QUESTIONS

National Concrete Bridge Council

Thank you!

Please sign up for future NCBC webinars

www.nationalconcretebridge.org

Photo: HNTB, © Core-Visual as seen in *ASPIRE* Summer 2023.