

SUNSHINE SKYWAY BRIDGE, FL



I-280 VETERANS' GLASS CITY SKYWAY, OH



VETERAN'S MEMORIAL BRIDGE, TX



Vessel Collision Evaluations for Segmental Concrete Bridges

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Senior Project Manager



SOUTH NORFOLK JORDAN BRIDGE, VA



Introduction

Introduction

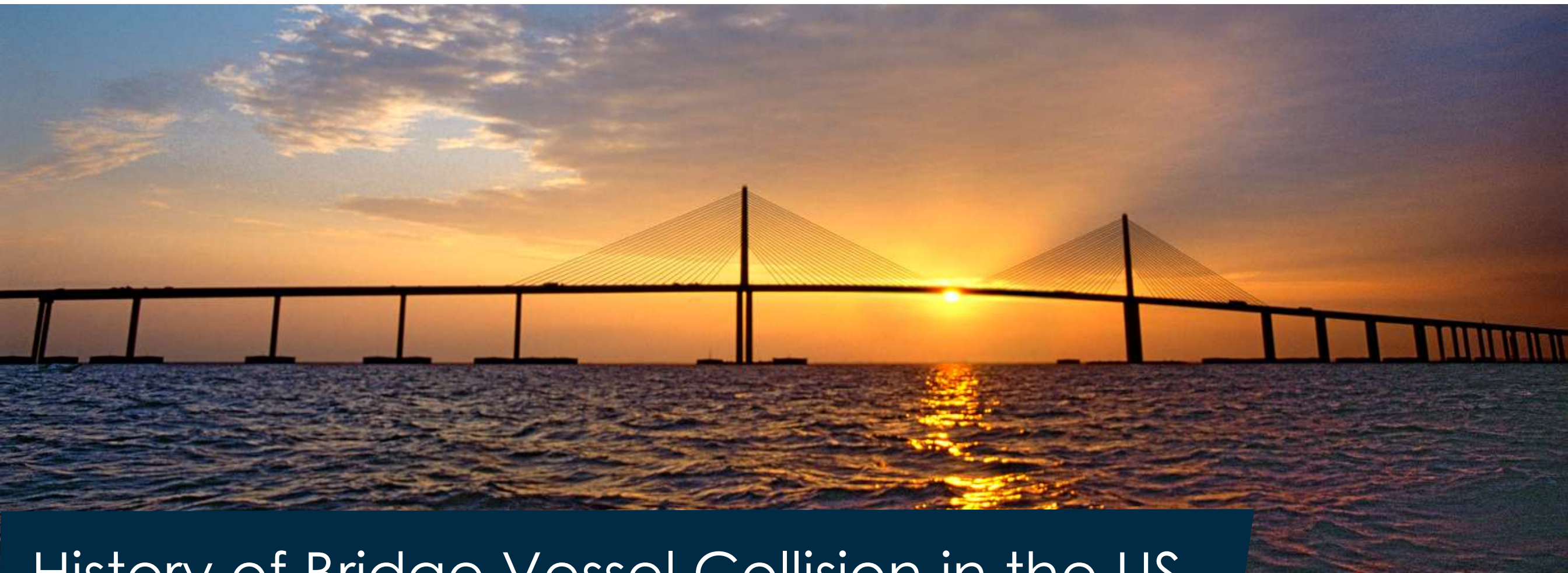
- History of Bridge Vessel Collision Analyses in the US
- Evolution of Bridge Vessel Collision Analyses in the US
- AASHTO Annual Frequency of Collapse



Introduction

- AASHTO Bridge Collision Forces
- AASHTO Extreme Limit State
- AASHTO Application of Impact Forces
- Major Bridge Vessel Collision Case Studies





History of Bridge Vessel Collision in the US

History of Bridge Vessel Collision in US

- Earliest Reports of Vessels Impacting Bridges date back to the mid 1600's in Developed Countries at that Time
- Some Bridges started to need Protection from Vessel Impacts during the First Industrial Revolution (~1760 to 1840)
- Ships and Bridges Continued to Grow Significantly in Size during the Second Industrial Revolution (~ 1870 to 1920)
- Vessels Grew Exponentially in Size During the Supertanker Era (~1956 to Present)
 - Largest Vessels in the Early 1950's Weighed Around 30,000 DWT
 - Largest Vessels in the 1970's Weighed over 500,000 DWT

History of Bridge Vessel Collision in US

- 36 Major Bridge Collapses due to Vessel Collisions Occurred Between 1960 and 2024
 - 19 Occurred in the US
 - Key Bridge Collapse in Baltimore, MD is the Largest in the US and Most Recent Major Collapse



History of Bridge Vessel Collision in US

- 28 of the 36 Major Bridge Collapses due to Vessel Collisions were Steel Bridges
 - 1972 - Sidney Lanier Bridge Collapse (Steel Plate Girder Bridge with Steel Vertical Lift Span), US, Brunswick, GA – [10 deaths, multiple Injuries]
 - 1983 – Ulyanovsk Bridge Collapse (Steel Truss Bridge), USSR, Ulyanovsk – [177 deaths, unknown large number injuries]
 - CSX Big Bayou Canot Bridge Collapse (Steel Through Truss Bridge), US, near Mobile, AL – [47 deaths, 103 injuries]
 - 2002 – I-40 Bridge Collapse (Steel Plate Girder Bridge), US, Webber Falls, OK – [14 deaths, 11 injuries]
 - 2024 – Francis Scott Key Bridge Collapse (Steel Cantilever Truss), US, Baltimore, MD – [6 deaths, 2+ injuries]

History of Bridge Vessel Collision in US

- 8 of the 36 Major Bridge Collapses due to Vessel Collisions were Concrete Bridges
 - 1975 – Tasman Bridge Collapse (Prestressed Concrete Girder Bridge, Australia, Hobart, Tasmania – [12 deaths (7 crewman, 5 motorists), 0 Injuries]
 - 2001 – Queen Isabella Causeway Collapse (Prestressed Concrete Girder Bridge), US, Port Isabel, TX – [8 deaths, 13 injuries]
 - 2024 – Lixinsha Bridge Collapse (Concrete Segmental Bridge), Peoples Republic of China, Guangzhou, Guangdong – [5 deaths, 3 injuries]

History of Bridge Vessel Collision in US

- 19 Major Bridge Collapses due to Vessel Collisions in the US

	Steel Bridges	Concrete Bridges
Number of Bridges in US Inventory	208,000	347,000
Number of Bridge Collapses	16	3
Percent of Bridge Collapses	0.0077%	0.0009%
Increase of Collapse Frequency	Roughly 9 Times More Steel Bridge Collapses than Concrete Bridge Collapses due to Vessel Collisions	

History of Bridge Vessel Collision in US

- Some Advantages of Concrete Bridges to Resist Collapse from a Vessel Collision Forces
 - Use of Compact Sections
 - No Fracture Critical Steel Elements
 - Typically Always Load Path Redundant
 - Structurally Redundant Superstructures
 - Typically Larger Substructure Elements
 - Foundations can Often Resist Larger Lateral Loads



History of Bridge Vessel Collision in US

- Sunshine Skyway Bridge Collapse on May 9, 1980 in Tampa, FL was the most Significant Event Related to Vessel Collision in the United States
 - 35 People Died falling over 150 feet into the Water
 - Over 1,200 Linear Feet of Superstructure Collapsed



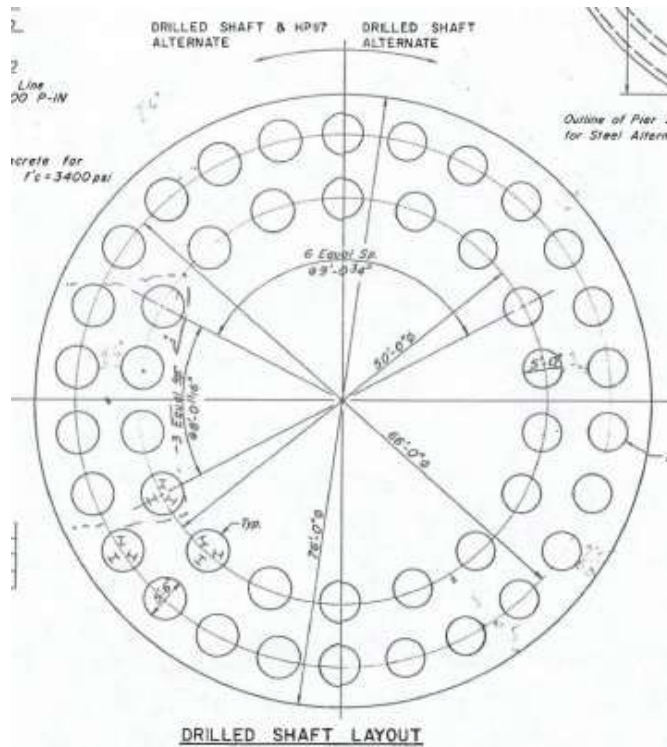
History of Bridge Vessel Collision in US

- Bridge Contactor (DBB):
 - Paschen Contractors, Inc.
- Engineer (Main Span & High Level Approach Spans):
 - Figg & Muller Engineering, Inc.
- Vessel Collision:
 - COWI Consulting Engineers and Planners AS
 - Developed a Project Specific Ship Collision Risk Assessment



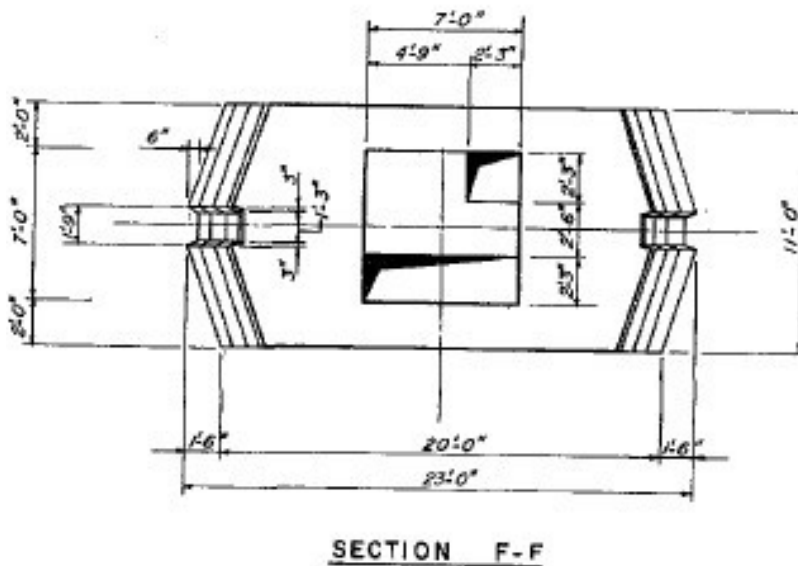
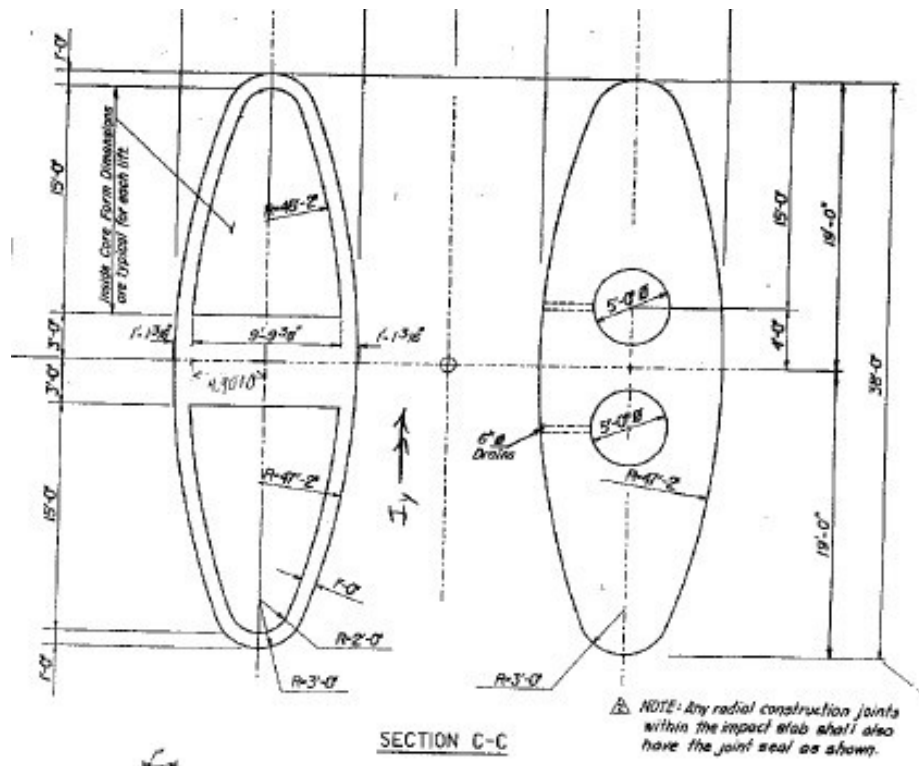
History of Bridge Vessel Collision in US

- Mainspan Pylons Drilled Shafts and Foundations
 - 44 – 5'-0" Diameter by 78'-0" Long Drilled Shafts
 - 140'-0" Diameter by 8'-0" Thick Reinforced Concrete Footing
 - 86'-0" Diameter by 25'-0" High Reinforced Concrete Pedestal



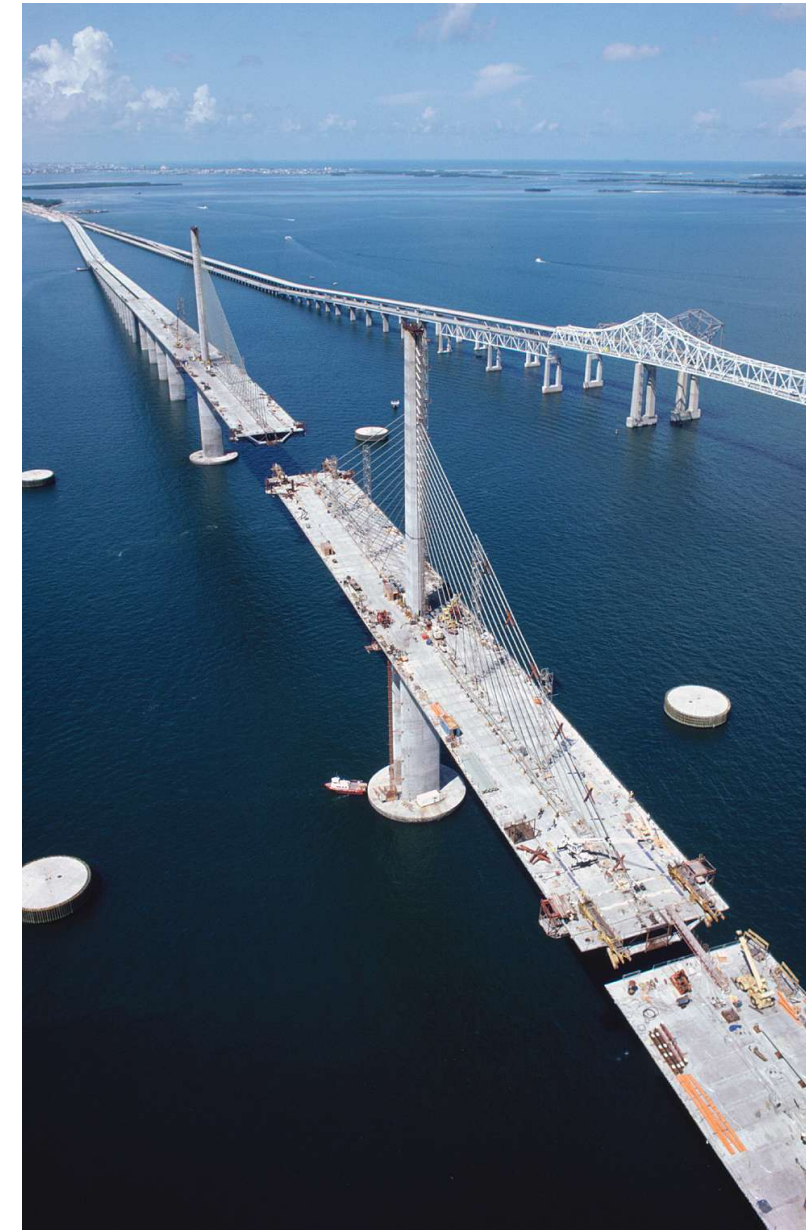
History of Bridge Vessel Collision in US

- Mainspan Lower Pylons and Upper Pylons
 - 38'-0" Wide by 12'-0" Long Dual Oval Shape with 2'-0" Thick Walls by 181'-3" High
 - 11'-0" Wide by 23'-0" to 14'-0" Long by 130'-0" High



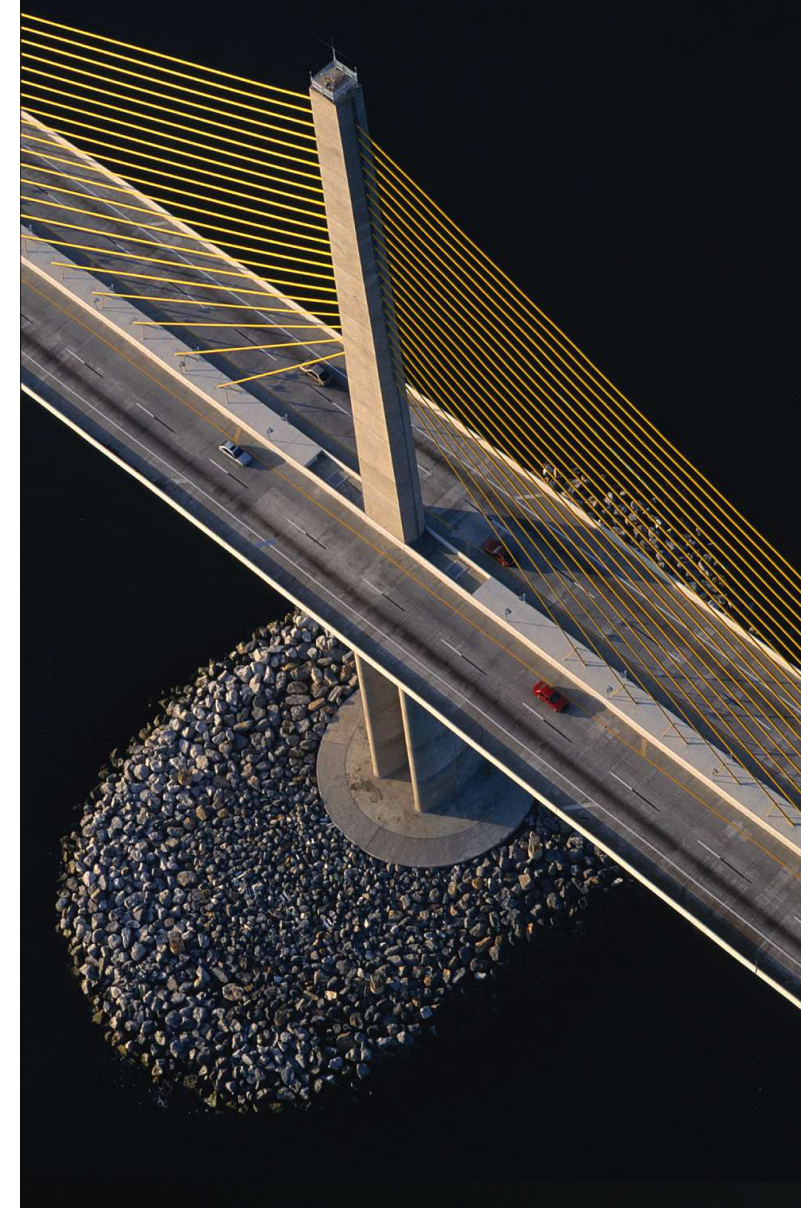
History of Bridge Vessel Collision in US

- Mainspan Superstructure
 - 94'-5" Wide by 14'-0" Long Precast Post Tensioned Segmental Concrete Superstructure Elements
 - 4,000'-0" Long Main Span Unit (140'-0", 3x240'-0", 540'-0", 1,200'-0", 540'-0", 3x540'-0" and 140'-0")



History of Bridge Vessel Collision in US

- Mainspan and High Level Approach Span Vessel Collision Protection
 - 450'-0" Wide by 330'-0" Long Rock Islands at Each Pylon (300'-0" by 180'-0" at Water Surface)
 - 2 – 76'-0" Diameter Cofferdams at Each Pylon
 - 32 – 60'-0" Diameter Cofferdams Around the Main Span Unit High Level Approach Piers



History of Bridge Vessel Collision in US

- Bob Graham Sunshine Skyway Bridge
 - Located in Tampa, FL
 - Built in 1987
 - Segmental Concrete Girder Cable-Stayed Bridge
 - Total Bridge Length = 21,860'
 - Main Span Length = 1,200'
- Navigation Channel Features
 - 1,000' Horizontal Clearance
 - 175' Vertical Clearance
 - 50' Water Depth at Normal Flow



History of Bridge Vessel Collision in US

- Designed Prior to the AASHTO Guide Specification
- Vessel Impact Design Loads
 - No Barge Impact Loads
 - $P_s = 12,000$ kips at 30° Skew Angle for Main Pylons
 - $P_s = 4,000$ kips for App. Piers
- Pier Protection Cofferdams Designed to Resist Impact Loads
- Rock Islands Designed to Resist Impact Loads at Pylons



History of Bridge Vessel Collision in US

- Multiple Research Projects began Shortly After the Collapse
- In 1988, a Pooled Research Fund Sponsored by 11 States and FHWA was develop to Turn the Research into a Guide Specification
- In 1991, The AASTO Guide Specification for Vessel Collision Design of Highway Bridges as Adopted

Publication No..FHWA-RD-91-006
December 1990

**Guide Specification and
Commentary for
Vessel Collision Design of
Highway Bridges
Volume I: Final Report**



U.S. Department of Transportation
Federal Highway Administration

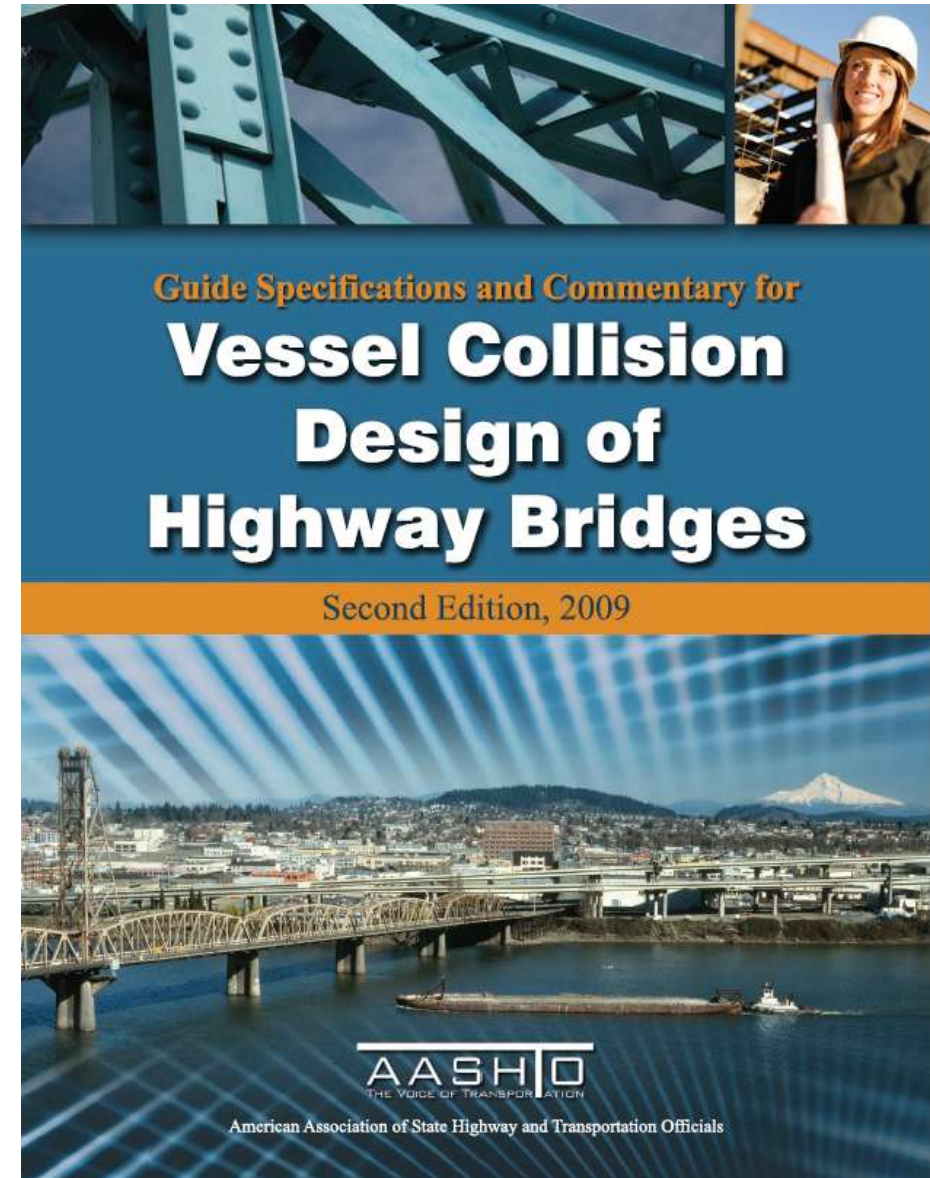
Office of Research and Development



Evolution of Vessel Collision in the US

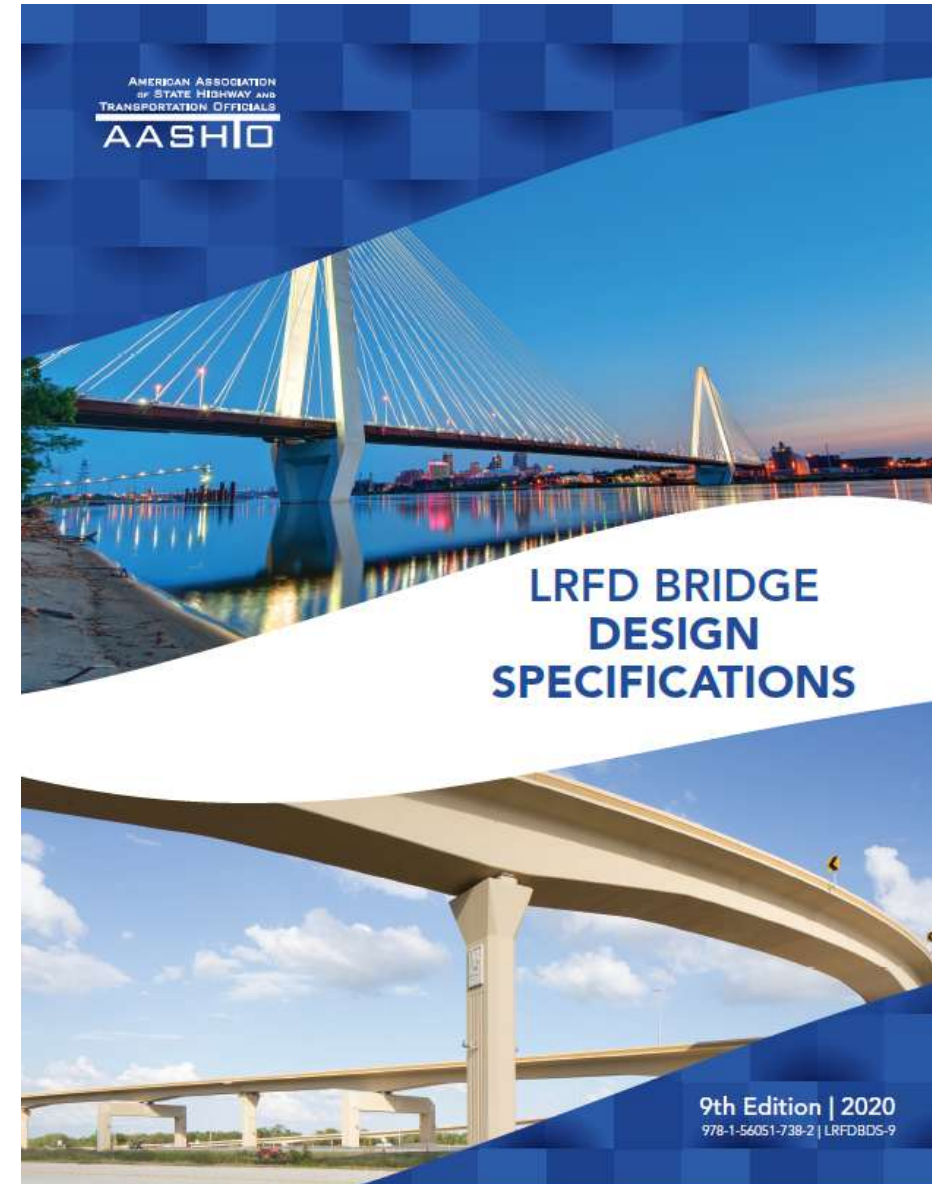
Evolution of Vessel Collision in the US

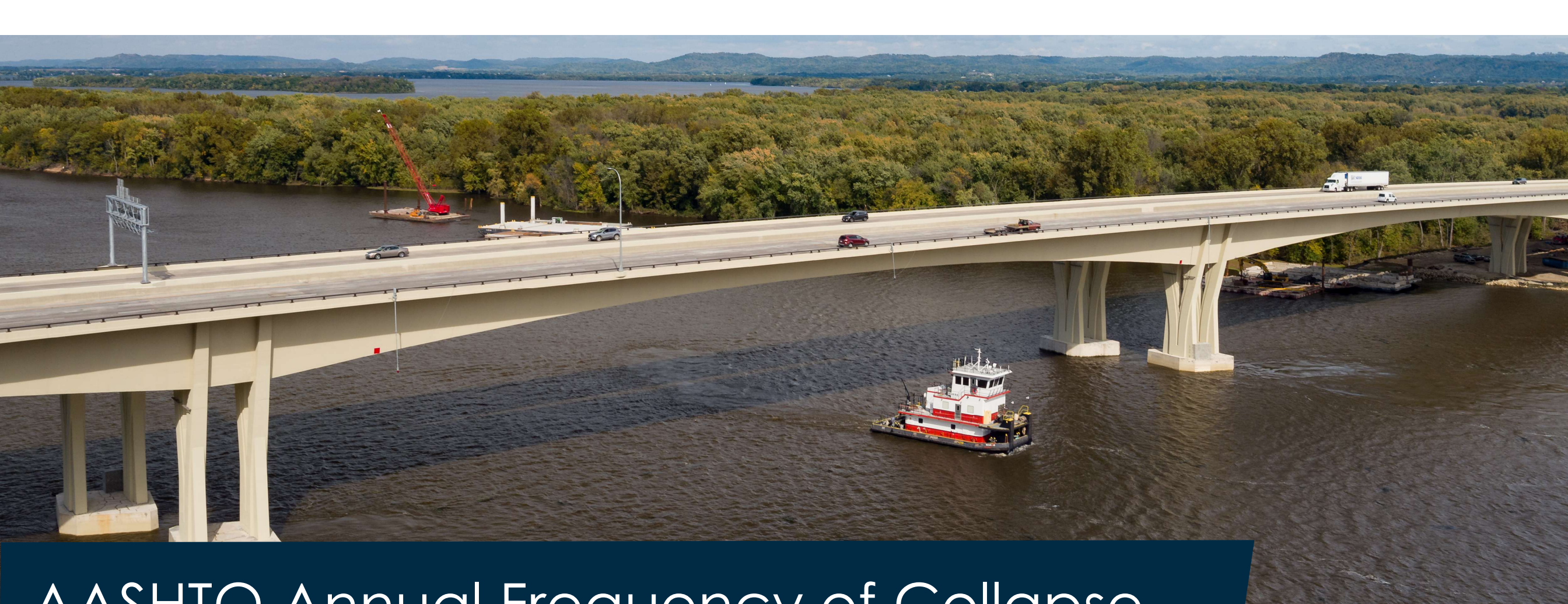
- In 2009, The 2nd Edition of AASHTO Guide Specification for Vessel Collision Design of Highway Bridges was Adopted
 - Included Many Updates to Vessel Statistics that was Based on Current Vessel Data
 - Updated to LRFD
 - Significantly Expanded Information in the Guide, Along with Analysis and Design Guidance



Evolution of Vessel Collision in the US

- The AASHTO LRFD Bridge Design Specifications adopted the main points of the Guide Specification as Code
 - The Guide Specification is still a Critical reference with over 240 pages of Information and Guidance Compared to about 20 pages of Code in AASHTO LRFD
- Bridges Designed before 1991 are Seeing an Increased Risk to Vessel Impact





AASHTO Annual Frequency of Collapse

AASHTO Annual Frequency of Collapse

- **All** Bridges over Navigable Waterways Shall be Designed to Resist a Minimum Design Impact Load (AASHTO, 3.14.1)
 - Design Barge Shall Be a Single 35'x195' Empty Hopper Barge with a Displacement of 200 tons Drifting at a Waterway Velocity Equal to the Yearly Mean Current
 - Design Water Depth is a Minimum of 2.0' Deep
- Shall Use Method II Risk Acceptance Alt. (AASHTO, C3.14.1)
 - More Complicated Probability-Based Analysis Procedure for Selecting the Design Vessel for Collision Impact
 - A Significant Amount of Input Data is Required
- Often an Iterative Process till the AASHTO Criteria is Met

AASHTO Annual Frequency of Collapse

- Owner's Responsibilities (AASHTO, 3.14.2)
 - Establish and/or Approve;
 - The Bridge's Operational Classification
 - Vessel Traffic Density in the Waterway
 - Design Velocity of the Vessels for the Bridge
 - Specify or Approve;
 - The Degree of Damage that the Bridge Components, Including Protective System, are Allowed to Sustain

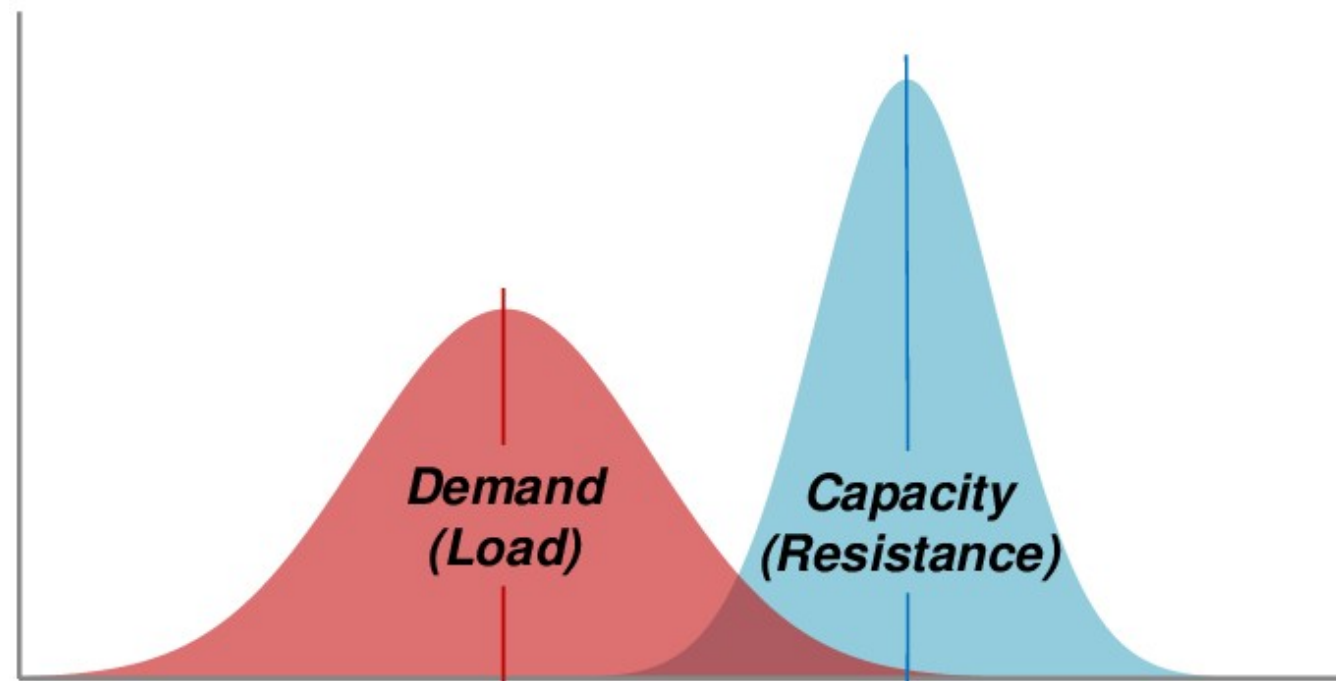


AASHTO Annual Frequency of Collapse

- Vessels Types that Don't need to be Considered in the Analysis
 - Ships Smaller than 1,000 DWT
 - Recreational Vessels
 - Special Purpose Vessels, Wood, or Fiberglass Vessels
- The AASHTO Specifications were Developed for Steel-Hulled Merchant Vessels and Barges
- Whole Bridge Annual Frequency of Collapse (AASHTO, 3.14.5)
 - $AF = (N)(PA)(PG)(PC)(PF)$
 - For Critical or Essential Bridges, $AF \leq 0.0001$ (1 in 10,000 yr.)
 - For Typical Bridges, $AF \leq 0.001$ (1 in 1,000 yr.)

AASHTO Annual Frequency of Collapse

- Why Must Engineers use Method II that is the More Complicated Probability-Based Analysis Procedure?
 - To Be Consistent with how Most of the Demands and Capacities are Calculated in AASHTO LRFD.



AASHTO Annual Frequency of Collapse

- AF Shall be Computed for Each Bridge Component and Vessel Classification.
 - AF = Annual Frequency of Bridge Component Collapse
- The Annual Frequency of Collapse for the Total Bridge Shall be Taken as the **Sum** of All Component AF's.
- The Acceptance Criterion for the Annual Frequency of Collapse Shall be Distributed over the Piers and Superstructure Components Located within the Distance of $3.0 \times \text{LOA}$ on Each Side of the Inbound and Outbound Vessel Centerline Paths.
 - LOA = Length of Overall Ship or Barge

AASHTO Annual Frequency of Collapse

- N = Annual Number of Vessels Based on;
 - Size
 - Type
 - Loading Condition
 - Water Depth
- “N” Shall be Developed for Each Pier and Span Component to be Evaluated



AASHTO Annual Frequency of Collapse

- The Determination of Vessel Frequency Distribution can Vary Significantly from Project to Project Based on Available Data
- Different Resources are Available to Help Piece Data Together
 - Bureau of Transportation Statistics
 - <https://www.bts.gov/ports>
 - US Army Corp of Engineers (USACE)
 - Waterborne Commerce Statistics Center (WCSC)
 - Nearby Ports or Locks
 - US Coast Guard (USCG)
 - Different Paid Services (i.e. Lloyd's Register)
 - Google Earth

AASHTO Annual Frequency of Collapse

- $PA = \text{Probability of Aberrancy} = (B_R)(R_B)(R_C)(R_{XC})(R_D)$

- B_R = Base Rate
 - 0.6×10^{-4} (for Ships) or 1.2×10^{-4} (for Barges)
- R_B = Correction Factor for Bridge Location
 - 1.0 (For Straight)
 - Formulas for Transition and Turn/Bend Regions
- R_C = Corr. Factor for Parallel to Current
 - V_C = Current Velocity (knots)
- R_{XC} = Perpendicular Current Corr. Factor
 - Data often not available
 - Often used 0.25 knots
- R_D = Correct Factory for Vessel Traffic Density
 - 1.0 (Low), 1.3 (Average) and 1.6 (High)

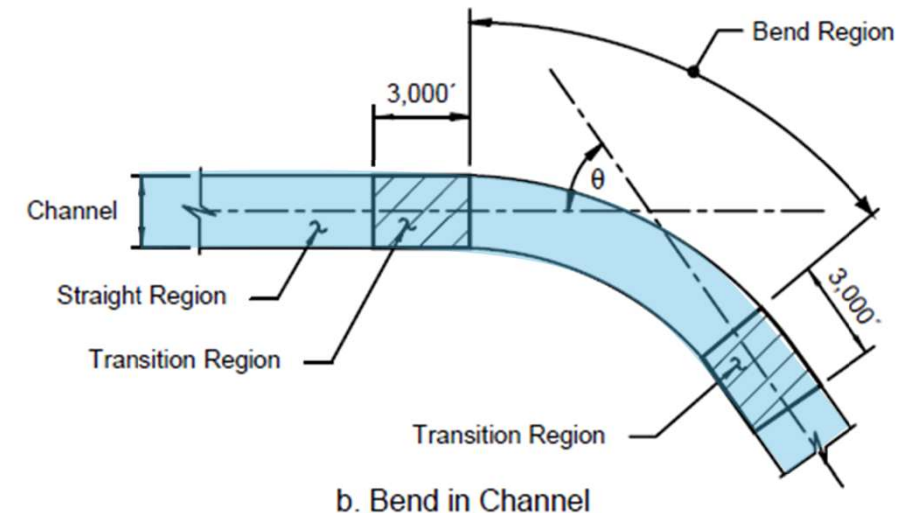
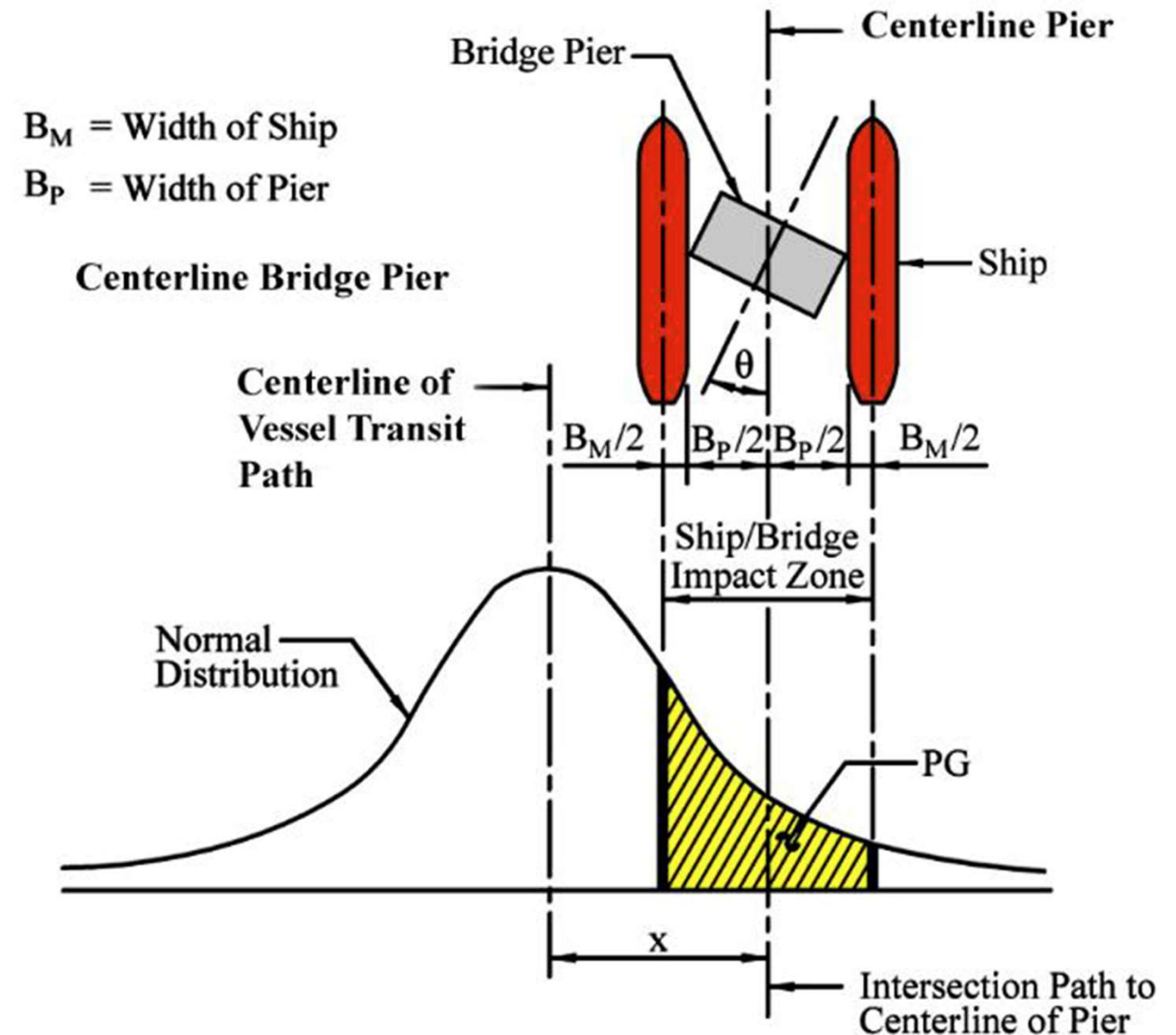


Figure 3.14.5.2.3-1 Waterway Regions for Bridge Location.

AASHTO Annual Frequency of Collapse

- PG = Geometric Probability
 - Need to Accurately Know the Geometry of the Bridge, Bridge Components, Channel, Design Vessels, Shipping Lanes and their Interrelations
 - Typically, a Lot of CAD Work Draw and Check the Geometry of All Elements
 - Determining the Probability that a Vessel will Hit a Pier if it has Lost Control



AASHTO Annual Frequency of Collapse

- PC = Probability of Collapse
 - Need to Know the Resistance of Bridge Component to a Horizontal Force Expressed as Pier Resistance (H)
 - Need to Know the Vessel Impact Force (P)
 - Often Simpler to Create a Minimum Ultimate Bridge Element Resistance to Design Too



AASHTO Annual Frequency of Collapse

- PF = Protection Factor
 - If the Pier(s) is 100% Protected, then $PF = 0.0$
 - If the Pier(s) is 0% Protected, then $PF = 1.0$
 - Need to the Know Geometry of the Protection System(s) (i.e. Dolphins, Fenders, Islands, etc.) in Addition to other Project Site Geometrical Information



AASHTO Annual Frequency of Collapse

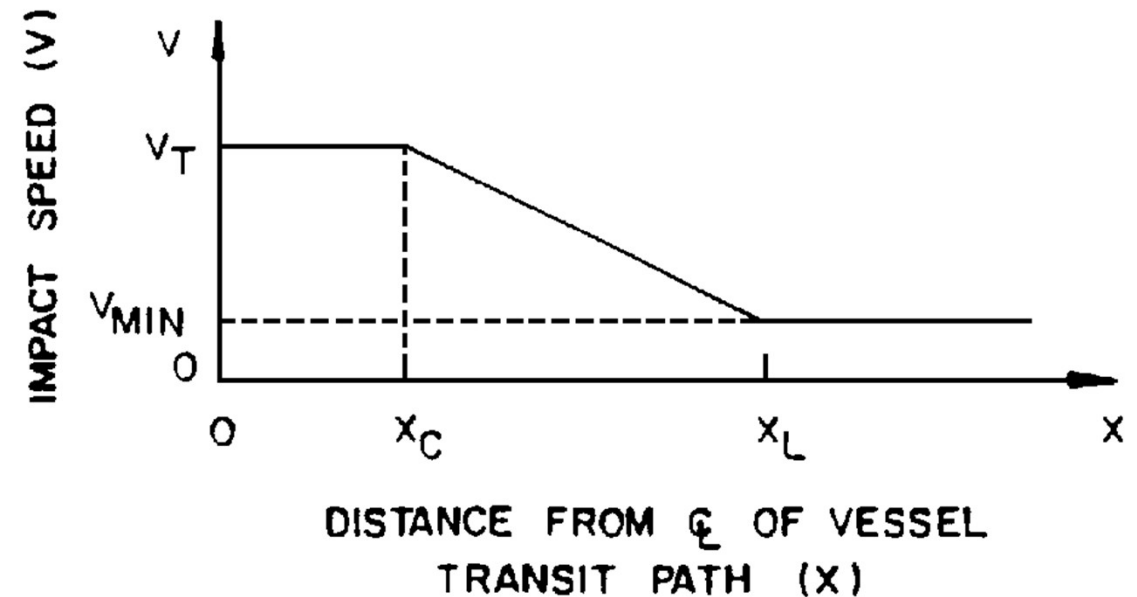
- Each Bridge Component Annual Frequency of Collapse
 - $AF_{ni} = (N)(PA)(PG)(PC)(PF)$
- Whole Bridge Annual Frequency of Collapse (AASHTO, 3.14.5)
 - $AF = AF_{n1} + AF_{n2} + AF_{n3} + AF_{ni}$
 - For Critical or Essential Bridges, $AF \leq 0.0001$ (1 in 10,000 yr.)
 - For Typical Bridges, $AF \leq 0.001$ (1 in 1,000 yr.)



AASHTO Collision Force

AASHTO Collision Force

- Design Collision Velocity (AASHTO 3.14.6)
 - V = Design Impact Velocity
 - V_T = Typical Vessel Transit Velocity
 - V_{MIN} = Not Less than YMCV
 - YMCV = Yearly Mean Curr. Vel.
 - X_C = Distance to Edge of Channel
 - $X_L = 3.0 * LOA$
 - X = Face to Pier to CL of Channel
- Need to Locate all Bridge Components in the Channel



AASHTO Collision Force

- Vessel Collision Energy (AASHTO 3.14.7)
 - $KE = \text{Vessel Collision Energy}$
 - $KE = (C_H * W * V^2) / 29.2$
 - W = Vessel Displacement Tonnage (Tonne)
 - V = Design Impact Velocity
 - C_H = Hydraulic Mass Coefficient
- Design Impact Velocity is Typically the Most Critical Component



AASHTO Collision Force

- Ship Collision Force on Pier (AASHTO 3.14.8)
 - P_s = Equivalent Static Vessel Impact Force
 - $P_s = 8.15 \cdot V \cdot \sqrt{DWT}$
 - V = Design Impact Velocity
 - DWT = Deadweight Tonnage of Vessel (tonne)
- Base Static Vessel Impact Force to Apply to Bridge Components
- Equation Based off Research Conducted by Woisin (1976) in West Germany Utilizing Large Scale Models

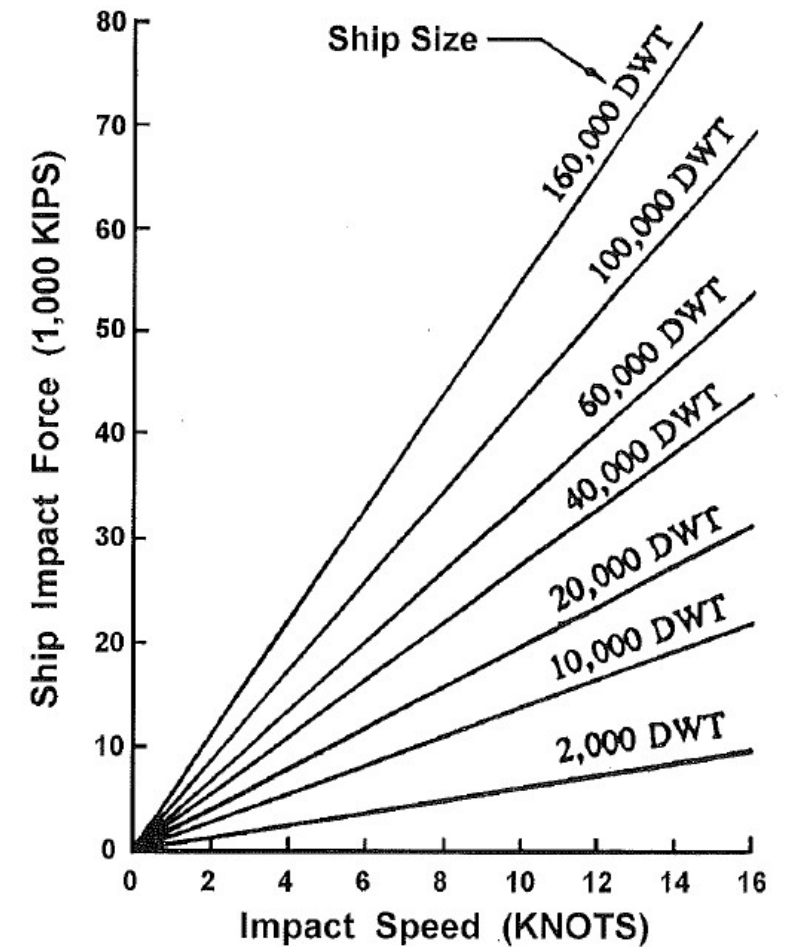
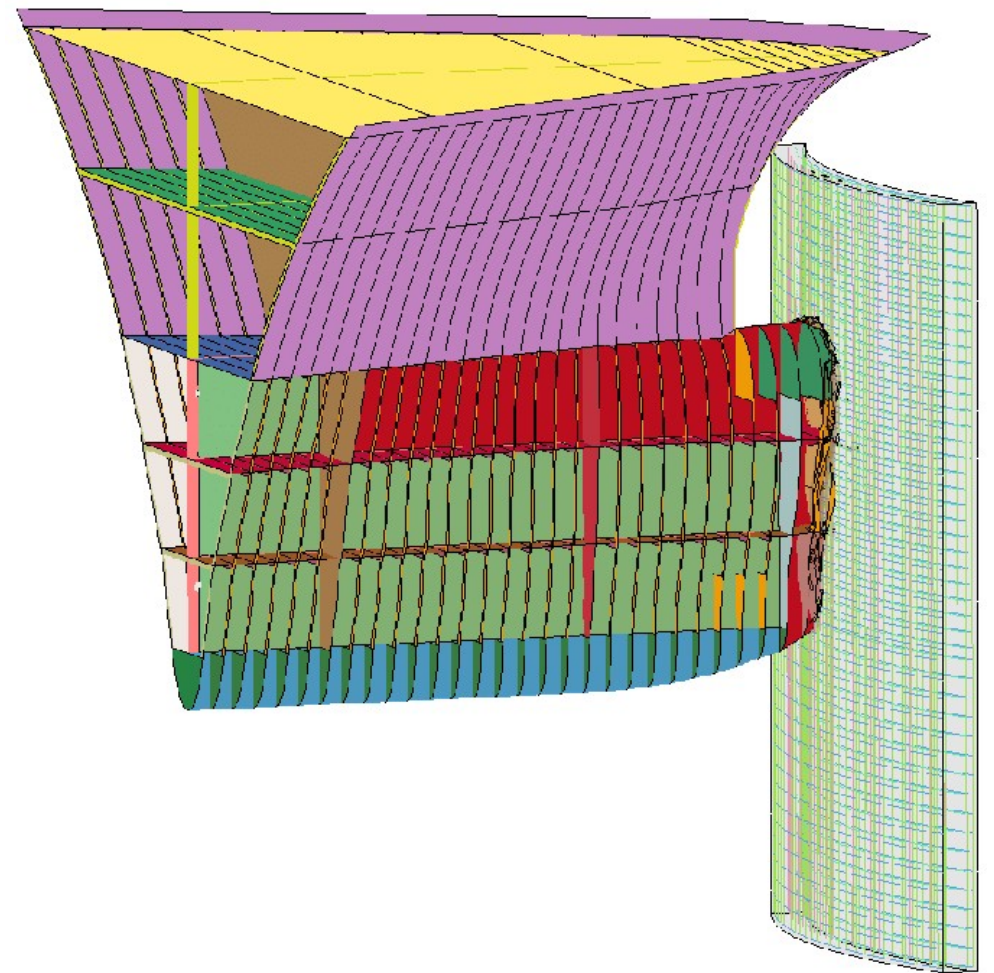


Figure C3.14.8-2 Typical Ship Impact Forces.

AASHTO Collision Force

- Ship Bow Damage Length (AASHTO 3.14.9)
 - a_s = Bow Damage Length of Ship
 - $a_s = 1.54(KE/P_s)$
 - KE = Vessel Collision Energy
 - P_s = Ship Impact Force
- Both Force and Bow Damage Length Must Be Considered
- As the Bow Crushes, it can Allow the Bow Overhang to Impact other Bridge Components



AASHTO Collision Force

- Collision with Bow (AASHTO 3.14.10.1)
 - P_{BH} = Ship Bow Impact Force
 - $P_{BH} = R_{BH} * P_S$
 - R_{BH} = Ratio of Exposed Superstructure Depth to Total Bow Depth
 - P_S = Ship Impact Force
- Can be a Significant Force on the Superstructure



AASHTO Collision Force

- Collision with Deck House on Superstructure (AASHTO 3.14.10.2)
 - P_{DH} = Ship Deck House Impact Force
 - $P_{DH} = R_{DH} * P_S$
 - R_{DH} = Reduction Factor Based on Vessel DWT
 - P_S = Ship Impact Force
- Remember to Consider Ballasted Vessels



AASHTO Collision Force

- Collision with Mast on Superstructure (AASHTO 3.14.10.3)
 - P_{MT} = Ship Deck House Impact Force
 - $P_{DH} = 0.10 * P_{DH}$
- Remember to Consider Ballasted Vessels
- Can Be a Significant Lateral Load on Superstructure Members



AASHTO Collision Force

- Barge Collision Force on Pier (AASHTO 3.14.11)
 - P_B = Equivalent Static Barge Impact Force
 - $P_B = 4,112 \cdot a_B$ (If $a_B < 0.34$)
 - $P_B = 1,349 + 110 \cdot a_B$ (If $a_B \geq 0.34$)
 - a_B = Barge Bow Damage Length
- Base Static Barge Impact Force to Apply to Bridge Components
- Equations Based off Research Conducted by Meir-Dornberg (1983) in West Germany Utilizing Large Scale Models

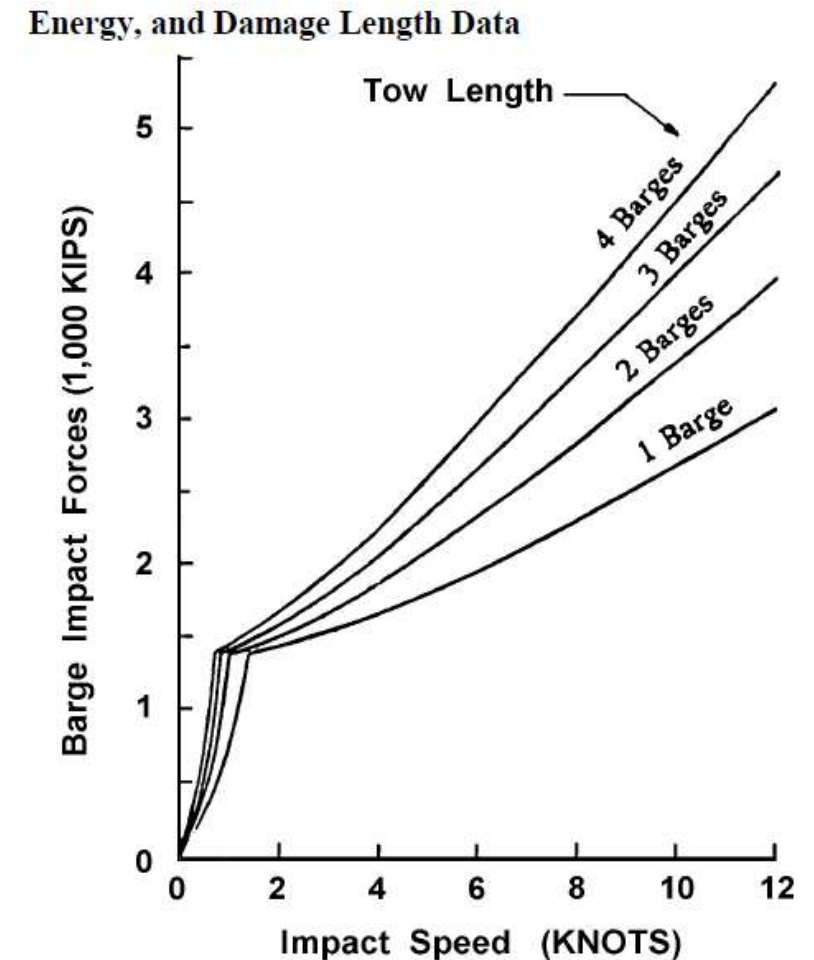


Figure C3.14.11-2—Typical Hopper Barge Impact Forces

AASHTO Collision Force

- Barge Bow Damage Length (AASHTO 3.14.12)
 - a_B = Bow Damage Length of Barge
 - $a_B = 10.2 * ((\sqrt{1 + (KE/5,672)}) - 1)$
 - KE = Barge Collision Energy
- Both Force and Bow Damage Length Must Be Considered
- Barge Bows can Extend far in front of the Hull, and Allow the Bow to Impact other Bridge Components

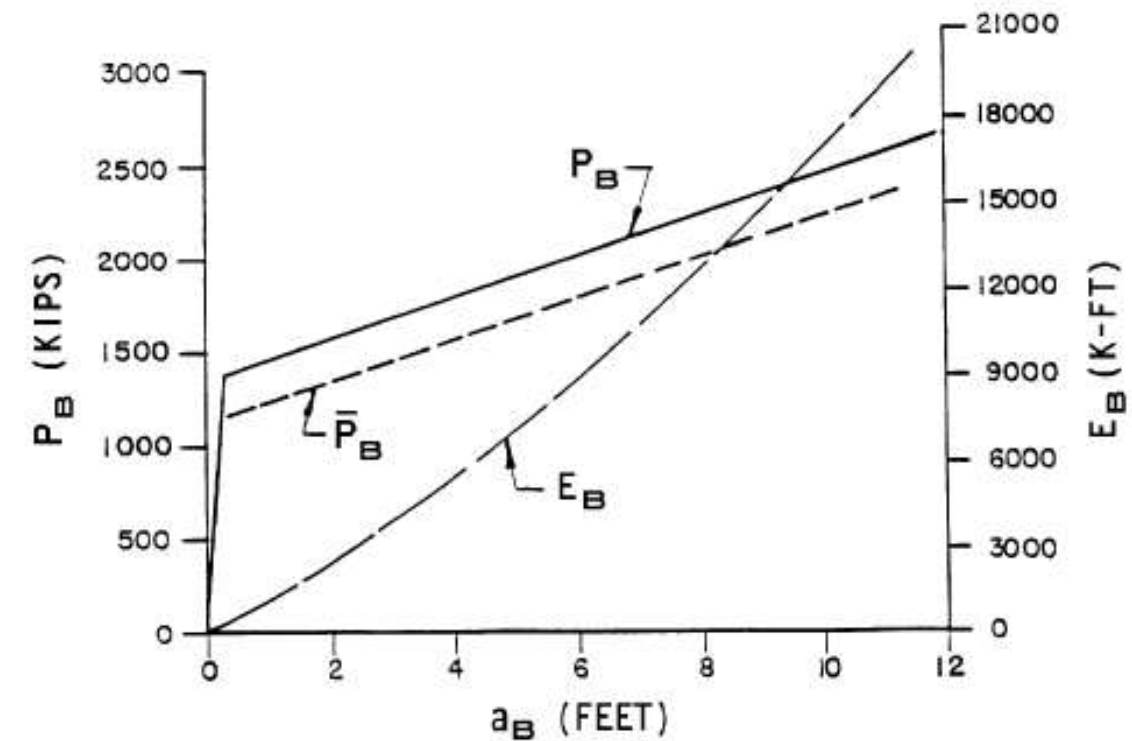
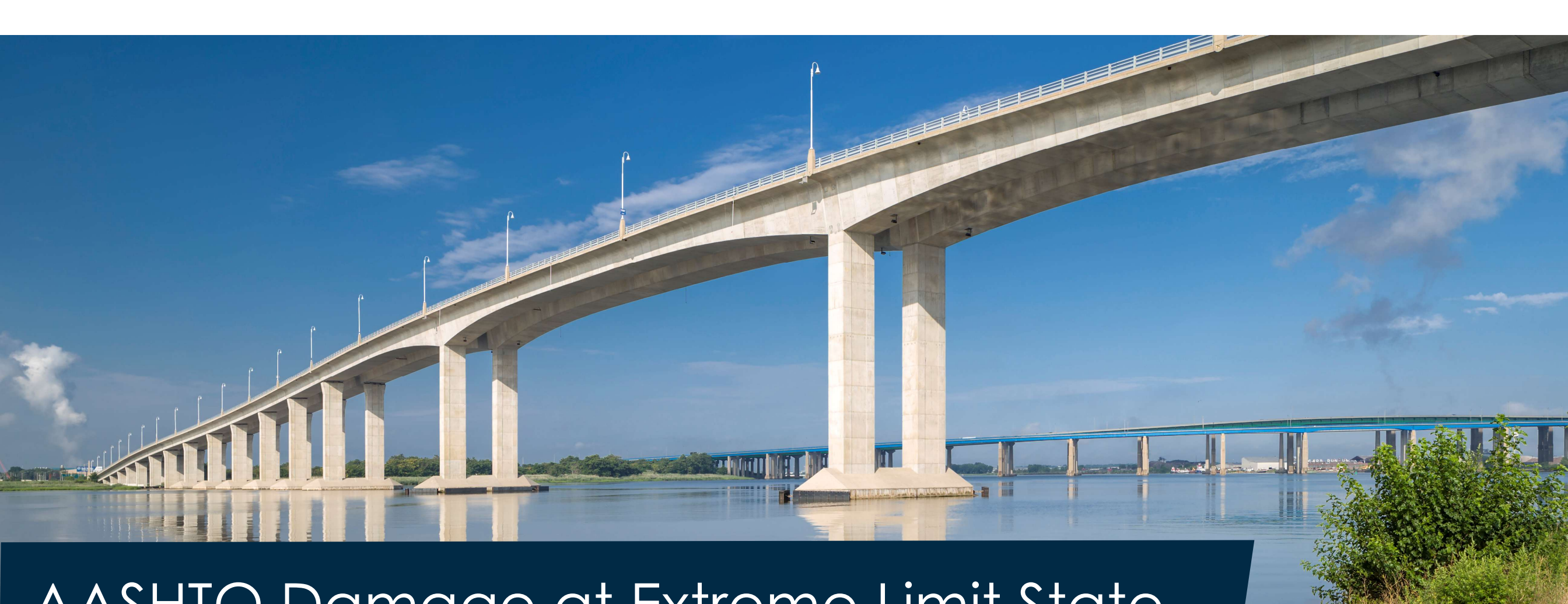


Figure C3.14.11-1—Barge Impact Force, Deformation



AASHTO Damage at Extreme Limit State

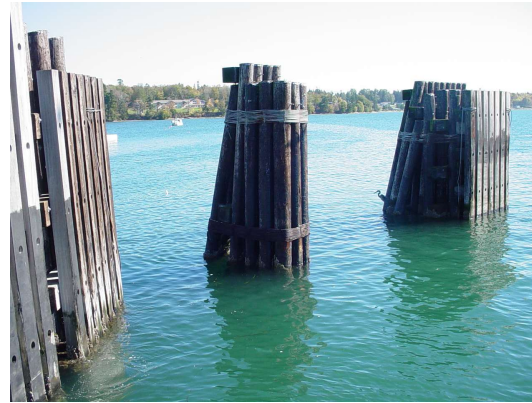
AASHTO Damage at Extreme Limit State

- Per AASHTO, 3.14.13, Inelastic Behavior and Redistribution of Force Effects is Permitted in Substructure and Superstructure Components, Provided that Sufficient Ductility and Redundancy Remain to Prevent Catastrophic Collapse.
- Pier Protection may be Provided to Eliminate or Reduce Vessel Collision Loads on Bridge Components, such as;
 - Fenders



AASHTO Damage at Extreme Limit State

- Typical Pier Protection to Eliminate or Reduce Vessel Collision Loads on Bridge Components
 - Pile-Supported Structures
 - Dolphins
 - Islands
 - Energy Dissipation Devices
 - Other Structure





AASHTO Application of Impact Forces

AASHTO Application of Impact Forces

- For Substructure Design (AASHTO, 3.14.14.1)
 - 100% of Design Impact Force Applied Parallel to Channel
 - 50% of Design Impact Force Applied Perpendicular to Channel
- Substructure Components Shall Consider Hull and/or Bow Impacts, Along with Impacts from Bow Overhang, Rake or Flair Distance of Ships and/or Barges
- Crushing of the Vessel's Bow Causing Impact with Any Setback Substructure Components Shall Also Be Considered
- Shall Consider Two Main Cases that are Overall Stability and Local Collision Forces

AASHTO Application of Impact Forces

- AASHTO Guide Specification

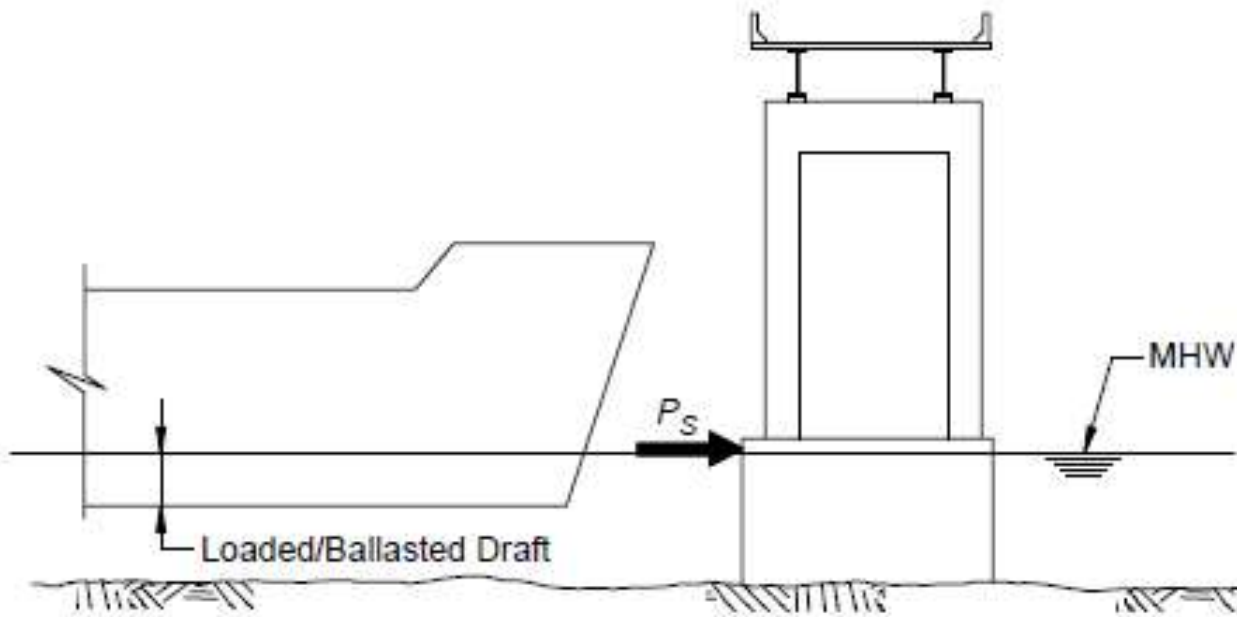


Figure 3.15.1-1—Ship Impact Concentrated Force on Pier (for Foundation Design and Overall Stability)

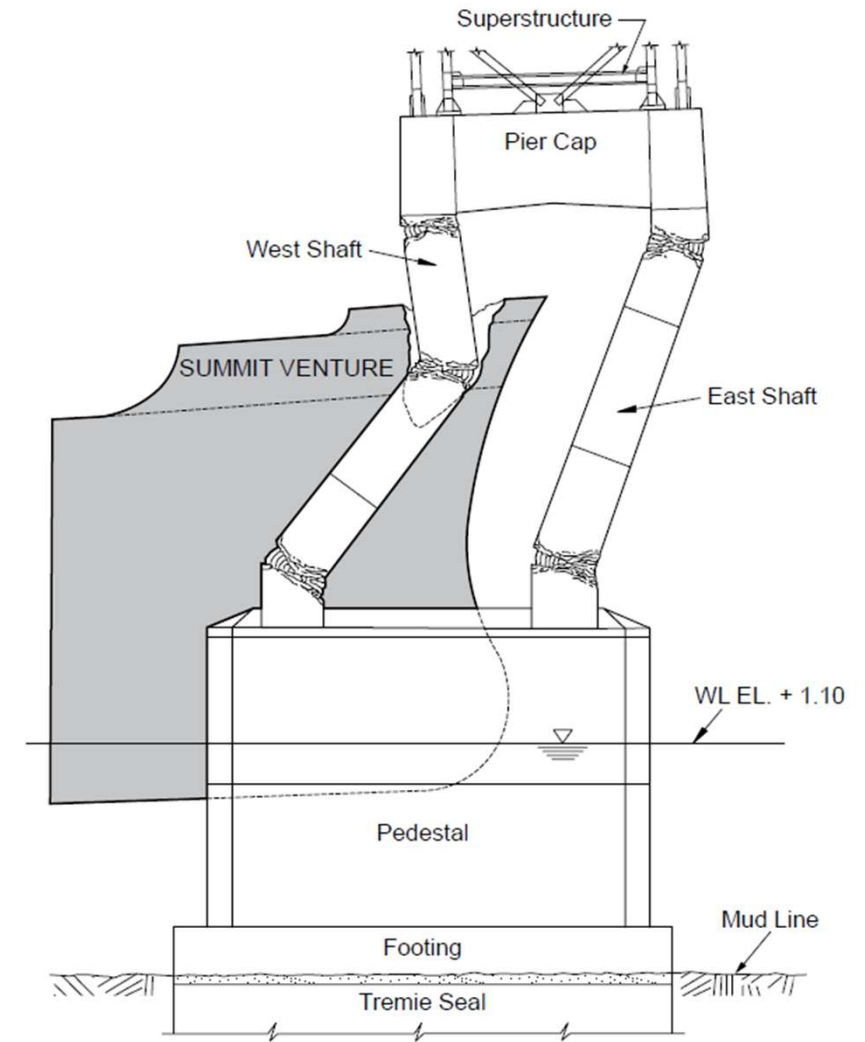


Figure C3.15.1-1—Collapse of Pier 2S of the Sunshine Skyway Bridge Subsequent to Impact by the Bow Overhang of the M/V Summit Venture

AASHTO Application of Impact Forces

- AASHTO Guide Specification

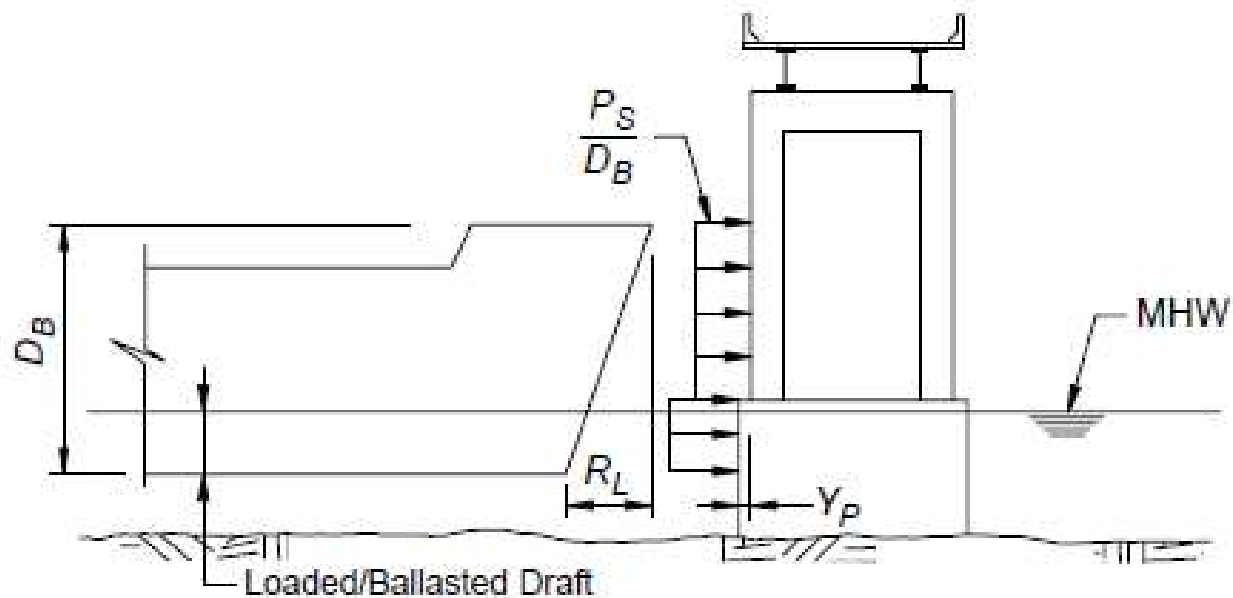


Figure 3.15.1-2—Ship Impact Line Load for Local Collision Force on Pier (for Structure Check and Design)

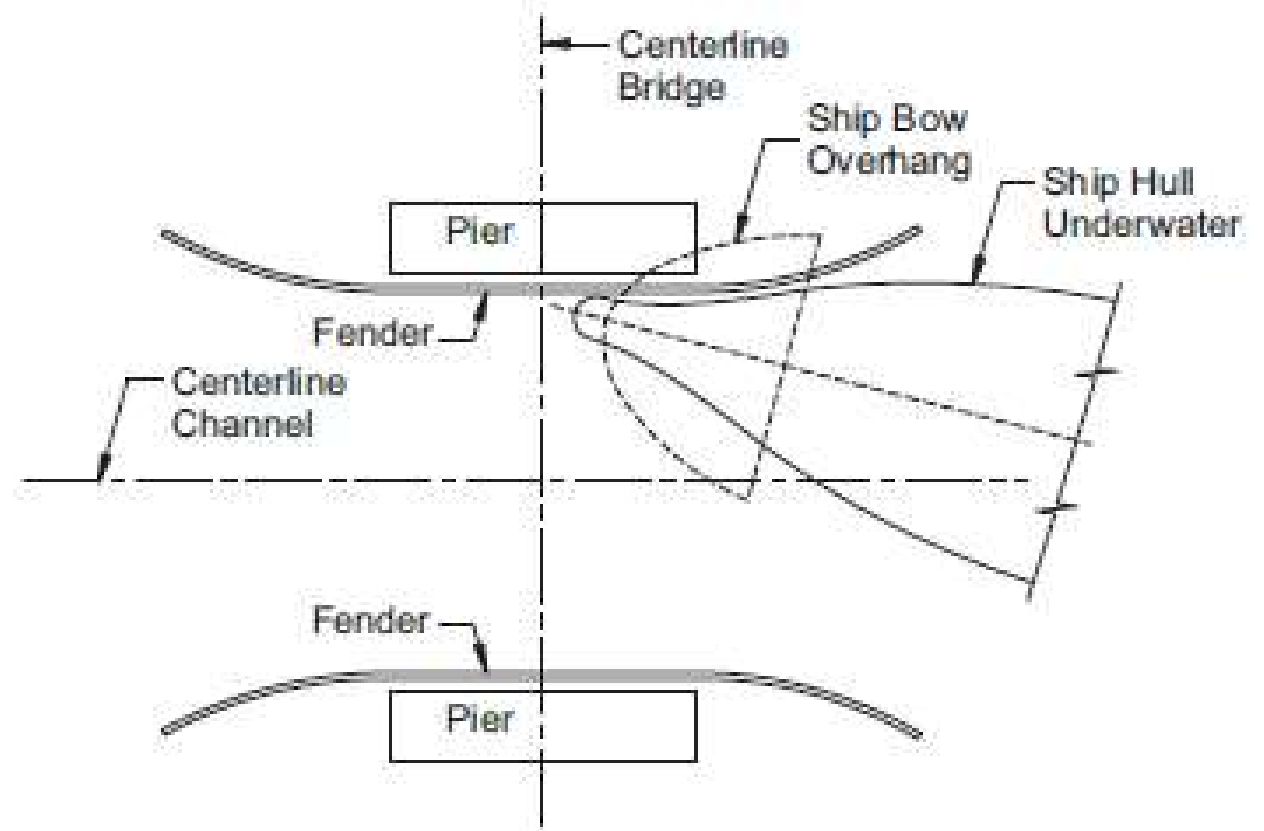


Figure C3.15.1-2—Plan of Ship Bow Overhang Impacting Pier Behind Fender

AASHTO Application of Impact Forces

- AASHTO Guide Specification

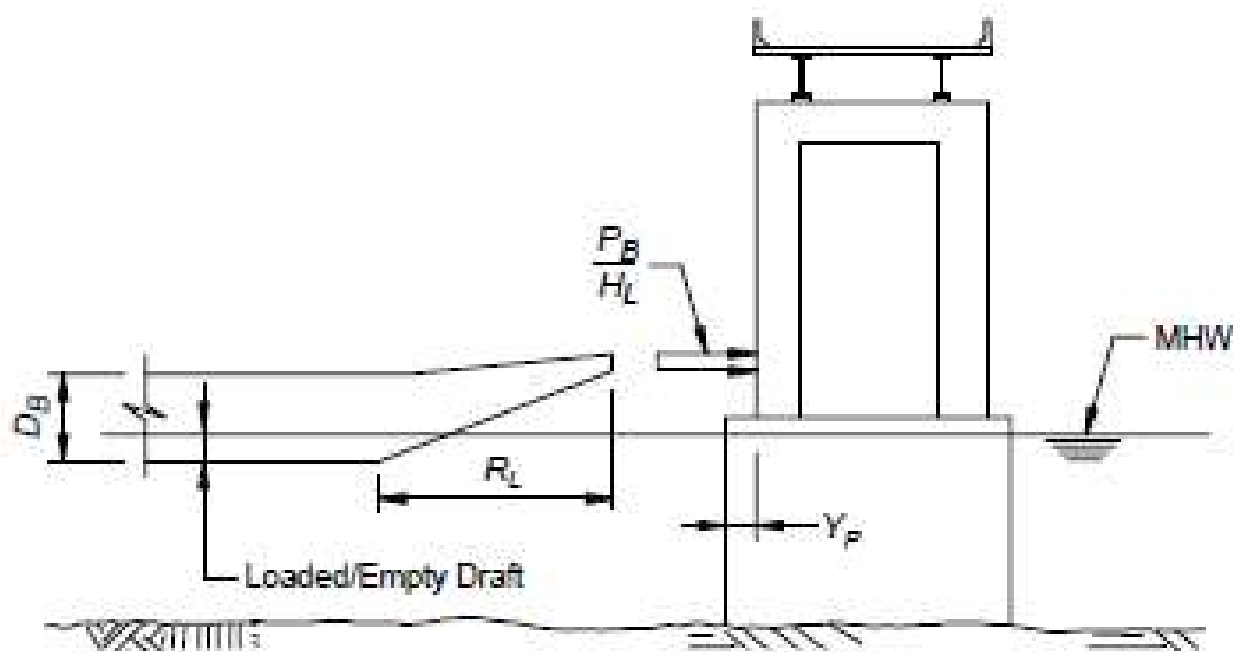


Figure 3.15.1-3—Barge Impact Line Load for Local Collision Force on Pier (for Structure Check and Design)

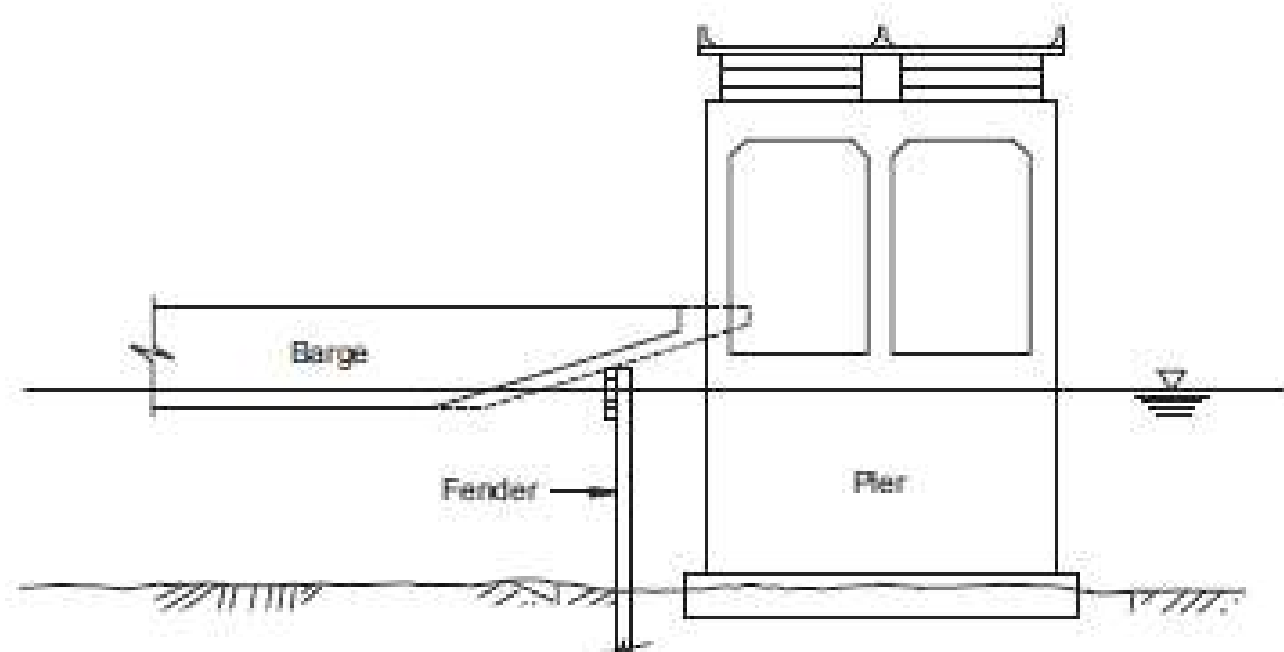
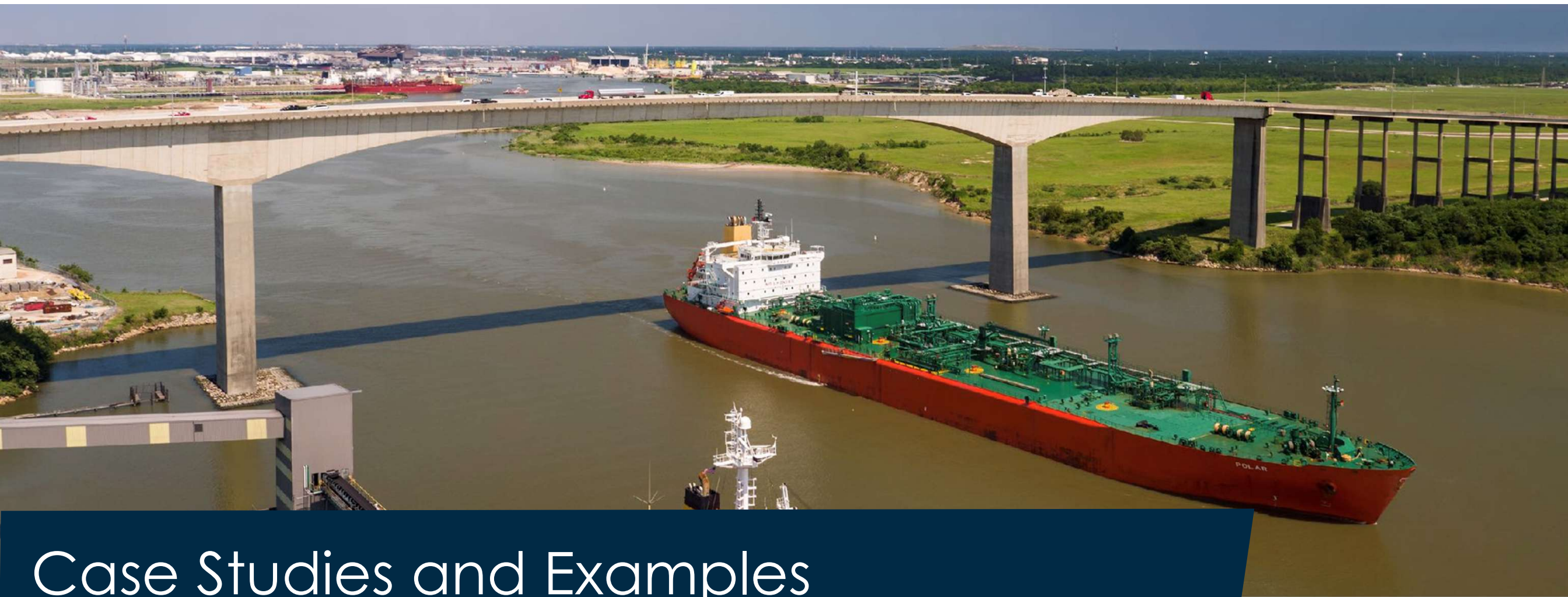


Figure C3.15.1-3—Elevation of Barge Overhang Impacting Pier Behind Fender



Case Studies and Examples

Case Studies and Examples

- Houston Ship Channel Bridge
 - Located in Houston, TX
 - Built in 1982
 - Segmental Concrete Girder Bridge
 - Total Bridge Length = 26,867'
 - Main Span Length = 750'
- Navigation Channel Features
 - 700' Horizontal Clearance
 - 175' Vertical Clearance
 - 50' Water Depth at Normal Flow



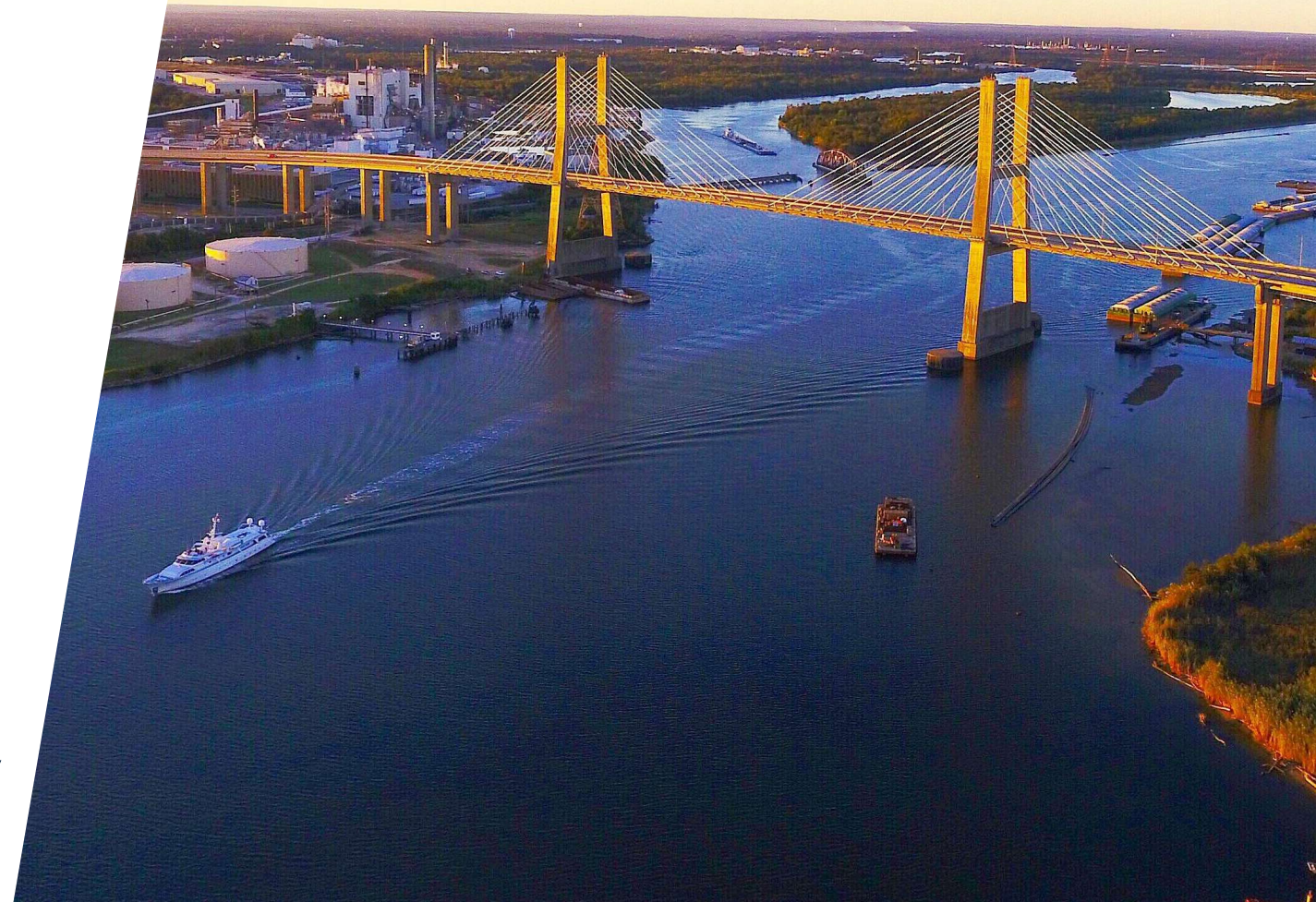
Case Studies and Examples

- Designed Prior to the AASHTO Guide Specification
- Vessel Impact Design Loads
 - No Barge Impact Loads
 - No Vessel Impact Loads
- Superstructure and Substructure Components were Designed to be Outside the Navigational Clearance Envelope
- Rock Islands Added Later



Case Studies and Examples

- Cochrane Bridge
 - Located in Mobile, AL
 - Built in 1991
 - Dual Box Segmental Concrete Girder Cable-Stayed Bridge
 - Total Bridge Length = 7,291'
 - Main Span Length = 750'
- Navigation Channel Features
 - 600' Horizontal Clearance
 - 140' Vertical Clearance
 - 45' Water Depth at Normal Flow



Case Studies and Examples

- Designed Prior to the AASHTO Guide Specification
- Vessel Impact Design Loads
 - No Barge Impact Loads
 - $P_s = 11,000$ kips at 30° Skew Angle for Main Towers
- Design to Resist Static Vessel Impact Loadings
- Pier Protection Cells are for Additional Protection



Case Studies and Examples

- Sidney Lanier Bridge
 - Located in Brunswick, GA
 - Built in 2003
 - Concrete Edge Girder CIP Cable-Stayed Bridge
 - Total Bridge Length = 7,779'
 - Main Span Length = 1,250'
- Navigation Channel Features
 - 400' Horizontal Clearance
 - 155' Vertical Clearance
 - 45' Water Depth at Normal Flow



Case Studies and Examples

- Vessel Impact Design Loads
 - No Barge Impact Loads
 - No Ship Impact Loads
 - No Scour at Main Towers
- Superstructure and Substructure Components were Designed to be Well Outside the Navigational Clearance Envelope
- Rock Islands Protect the Main Towers



Case Studies and Examples

- Penobscot Narrows Bridge
 - Located in Prospect-Verona, ME
 - Built in 2006
 - Segmental Concrete Girder Cable-Stayed Bridge
 - Total Bridge Length = 2,120'
 - Main Span Length = 1,161'
- Navigation Channel Features
 - 428' Horizontal Clearance
 - 135' Vertical Clearance
 - 100' Water Depth at Normal Flow



Case Studies and Examples

- Vessel Impact Design Loads
 - No Barge Impact Loads
 - No Ship Impact Loads
 - No Scour at Main Towers
- Superstructure and Substructure Components were Designed to be Well Outside the Navigational Clearance Envelope



Case Studies and Examples

- Jordan Bridge
 - Located in Chesapeake, VA
 - Built in 2012
 - Segmental Concrete Girder Bridge
 - Total Bridge Length = 5,372'
 - Main Span Length = 385'
- Navigation Channel Features
 - 270' Horizontal Clearance
 - 145' Vertical Clearance
 - 30' Water Depth at Normal Flow
 - 46' Water Depth at 100 Year Flood



Case Studies and Examples

- Vessel Impact Design Loads
 - No Barge Impact Loads
 - Ship Impact Loads
 - $P_B = 9,005$ kips at El. 1.17 Feet
 - Design Vessel Velocity = 5.9 ft/s
- Ring Beams are Designed to Dissipate the Direct Impact from an 80,000 DWT Vessel thru Large Displacement
- Main Piers Fully Protected from Vessel Impact



Case Studies and Examples

- Sarah Mildred Long Bridge
 - Located in Kittery, ME
 - Built in 2018
 - Segmental Concrete Girder Bridge & Steel Lift Span
 - Total Bridge Length = 2,368'
 - Main Span Length = 335'
- Navigation Channel Features
 - 16' Low Horizontal Clearance
 - 56' Middle Vertical Clearance
 - 135' Middle Vertical Clearance
 - 70' Water Depth at Normal Flow



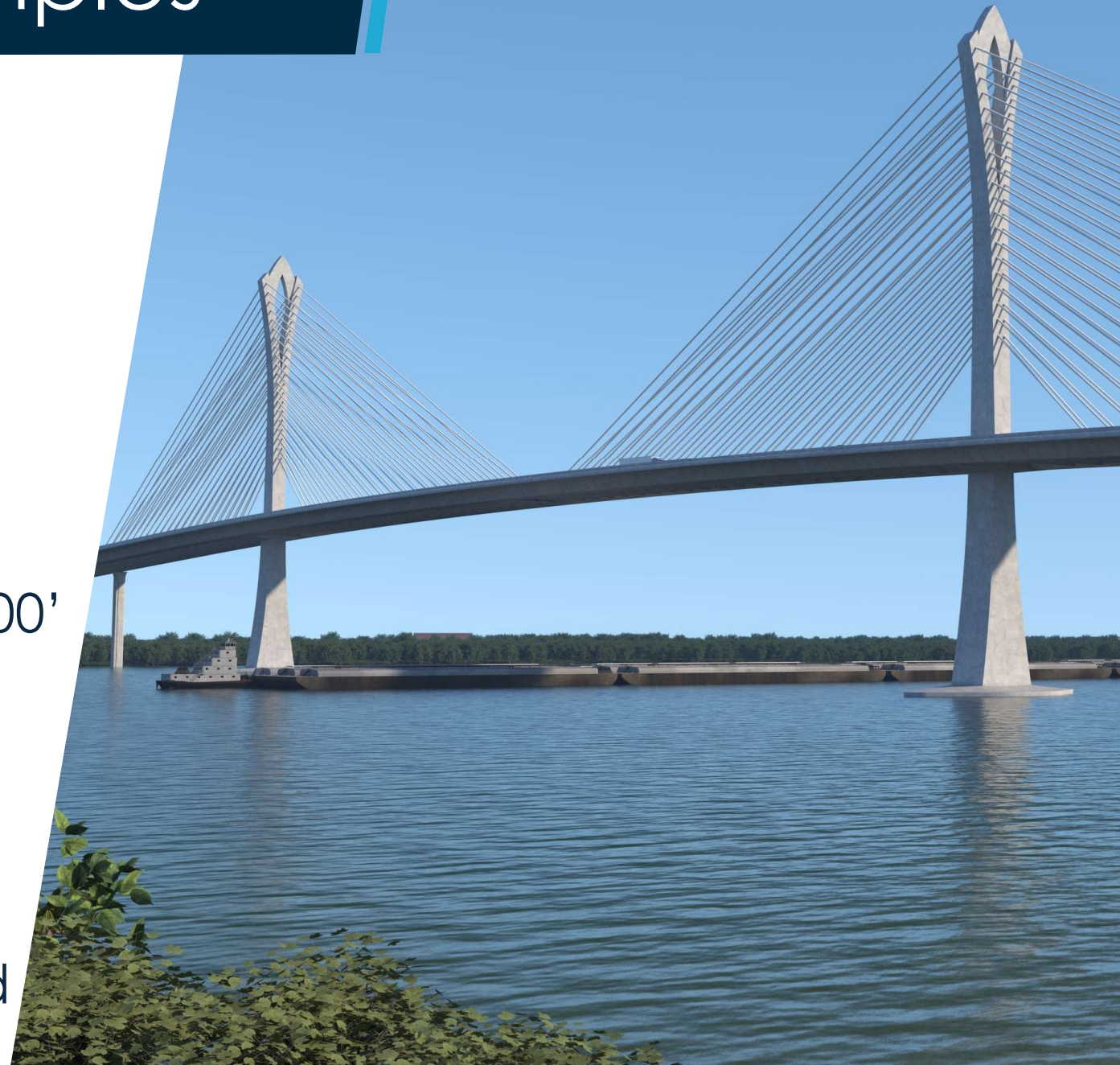
Case Studies and Examples

- Vessel Impact Design Loads
 - No Barge Impact Loads
 - Ship Impact Loads
 - $P_S = 2,000$ kips
 - $P_{BH} = 500$ kips
 - Design Vessel Velocity = 5.0 ft/s
- Designed as Typical Bridge
- Substructure and Superstructure Designed to Resist Static Vessel Impact Loadings without Additional Protections



Case Studies and Examples

- New Mississippi River Bridge
 - Located in Baton Rouge, LA
 - Currently in Environmental Stage
 - Vessel Impact Study in 2023
 - Cable Stayed Main Span
 - Total Bridge Length = 4 to 6 miles
 - Main Span Length = 1,600' to 1,900'
- Navigation Channel Features
 - 750' Horizontal Clearance
 - 135' Vertical Clearance
 - 60' Water Depth at Normal Flow
 - 100' Water Depth at 100 Yr. Flood



Case Studies and Examples

- Vessel Impact Design Loads
 - Ship Impact Loads
 - $P_s = 18,750$ kips at El. 3.0 Feet
 - $P_s = 21,750$ kips at El. 16.0 Feet
 - $P_s = 31,750$ kips at El. 42.5 Feet
 - Design Stream Flow = 11.5 ft/s at 100 Year Flood
 - Scour is being considered
- Design to Resist Static Vessel Impact Loadings
- Additional Pier Protection



Case Studies and Examples

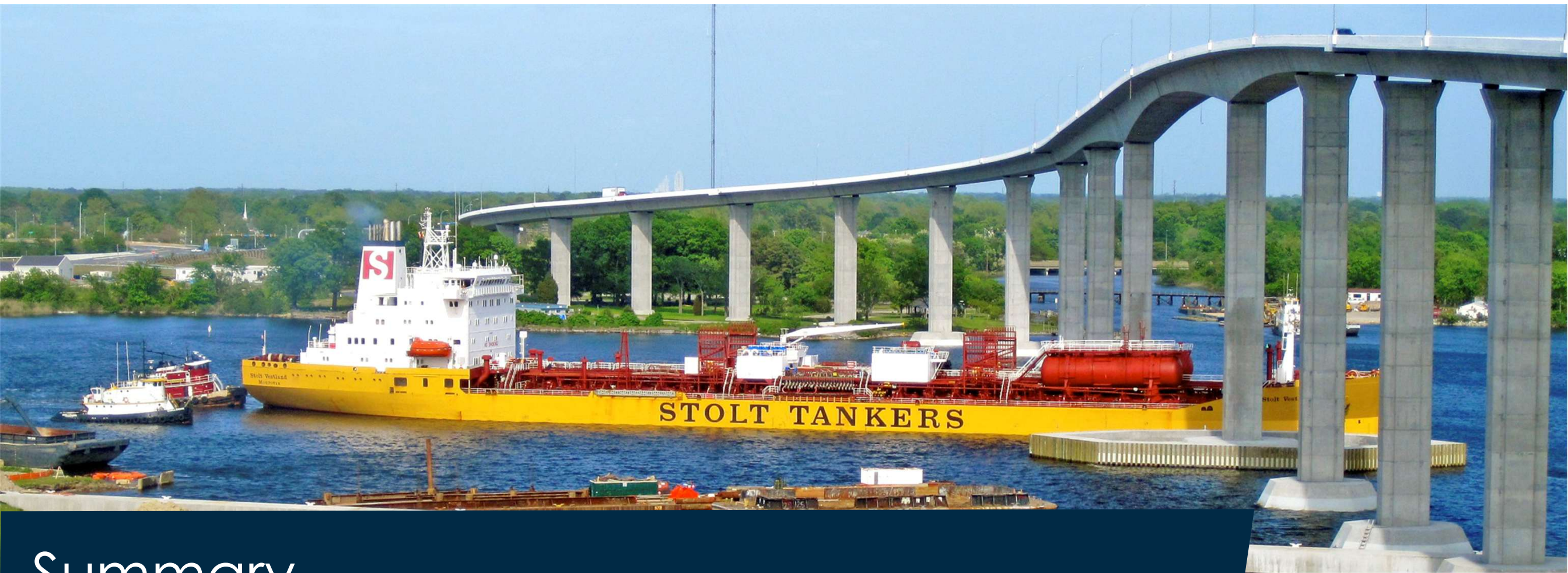
- Putnam Bridge
 - Located in Hartford, CT
 - Built in 1958
 - Vessel Impact Study in 2024
 - Steel Plate Girder Bridge
 - Total Bridge Length = 2,393'
 - Main Span Length = 319'
- Navigation Channel Features
 - 150' Horizontal Clearance
 - 80' Vertical Clearance
 - 10' Water Depth at Normal Flow
 - 45' Water Depth at 100 Yr. Flood



Case Studies and Examples

- Vessel Impact Design Loads
 - Barge Impact Loads
 - $P_B = 504$ kips at El. 12.0 Feet
 - $P_B = 712$ kips at El. 46.0 Feet
 - No Ship Impact Loads
 - Design Stream Flow = 4.2 ft/s at 100 Year Flood
 - 30.0' of Scour at 100 Year Flood
- Design to Resist Static Vessel Impact Loadings without Additional Pier Protection





Summary

Summary

- History of Bridge Vessel Collision Analyses in the US
- Evolution of Bridge Vessel Collision Analyses in the US
- AASHTO Annual Frequency of Collapse



Summary

- AASHTO Bridge Collision Forces
- AASHTO Extreme Limit State
- AASHTO Application of Impact Forces
- Major Bridge Vessel Collision Case Studies



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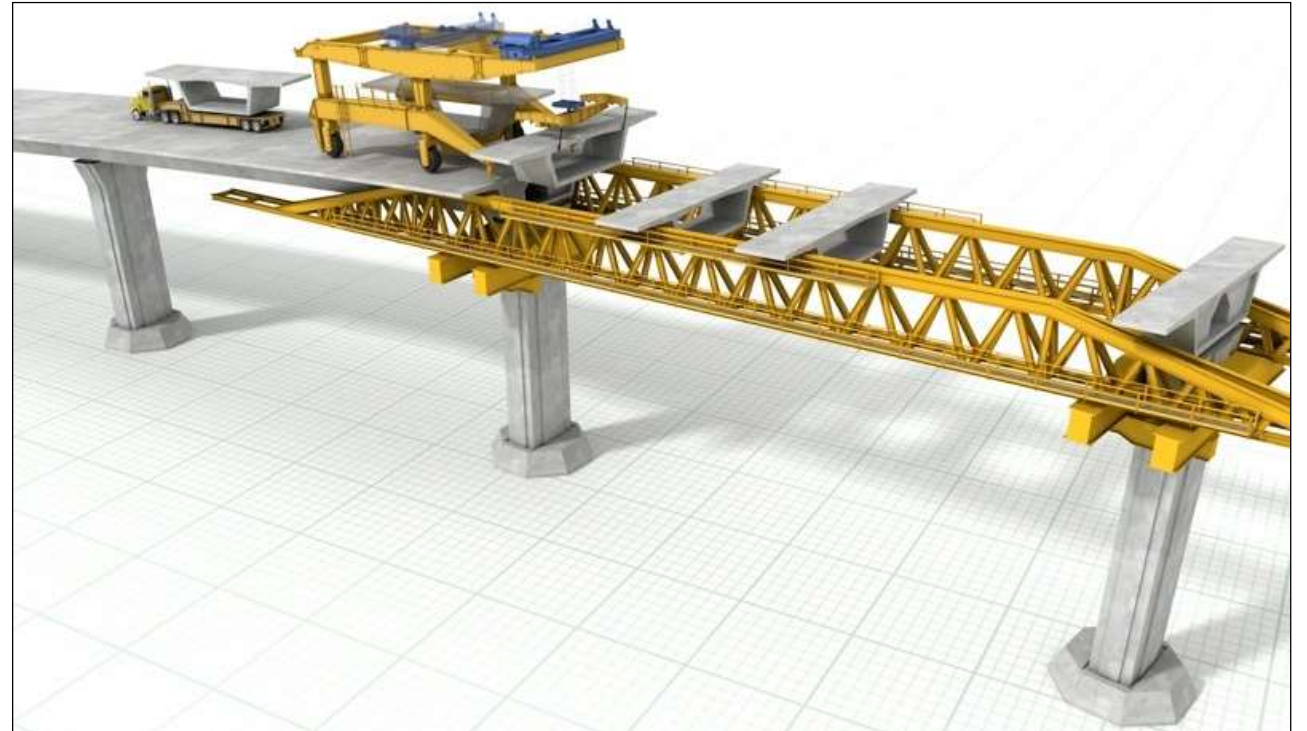
CONSTRUCTION PRACTICES HANDBOOK FOR CONCRETE SEGMENTAL & CABLE-SUPPORTED BRIDGES

Published June 2026.

ASBI
American Segmental Bridge Institute

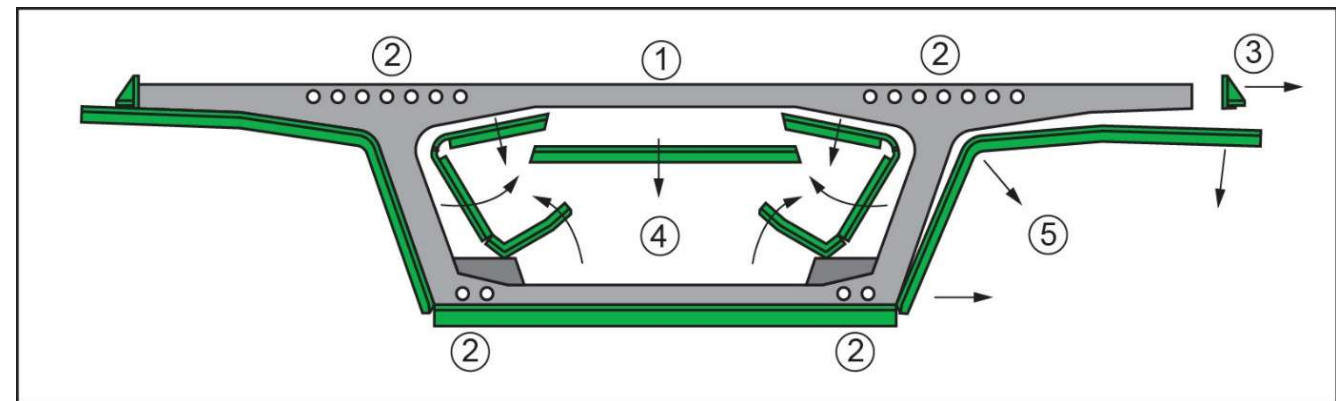
Construction Practices Handbook, 4th Edition

- Over 50 pages of new knowledge and information added to the 4th Edition
- Now over 500 pages of segmental bridge construction knowledge



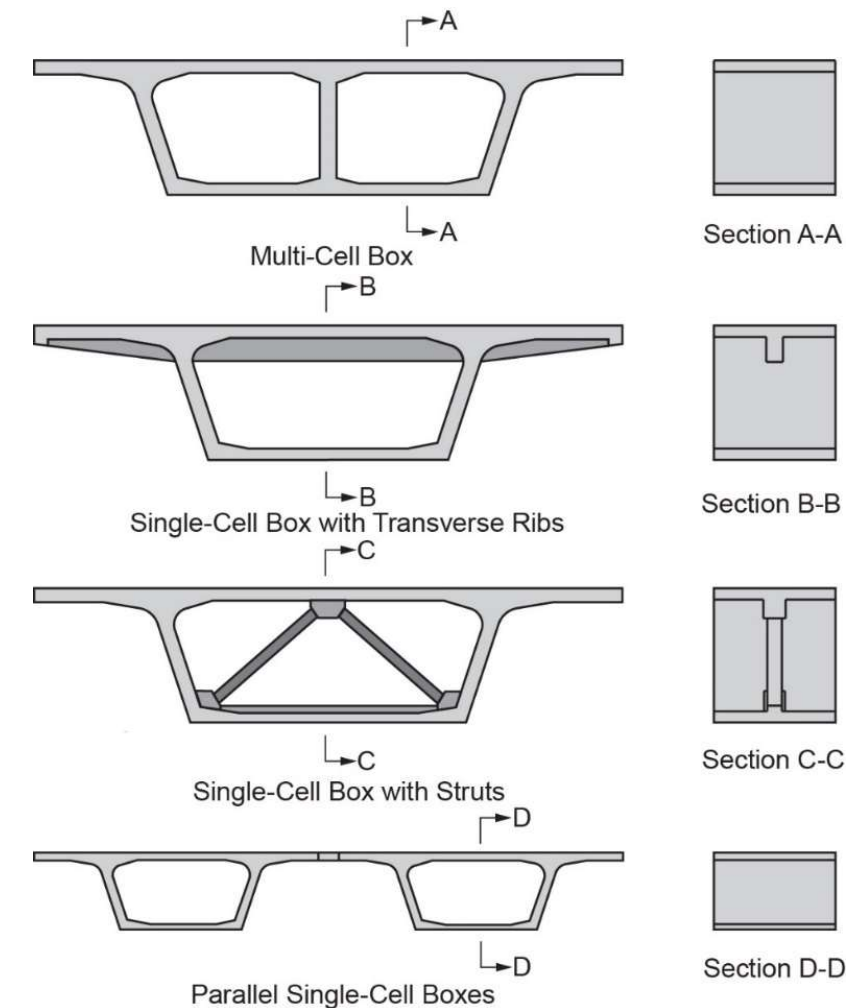
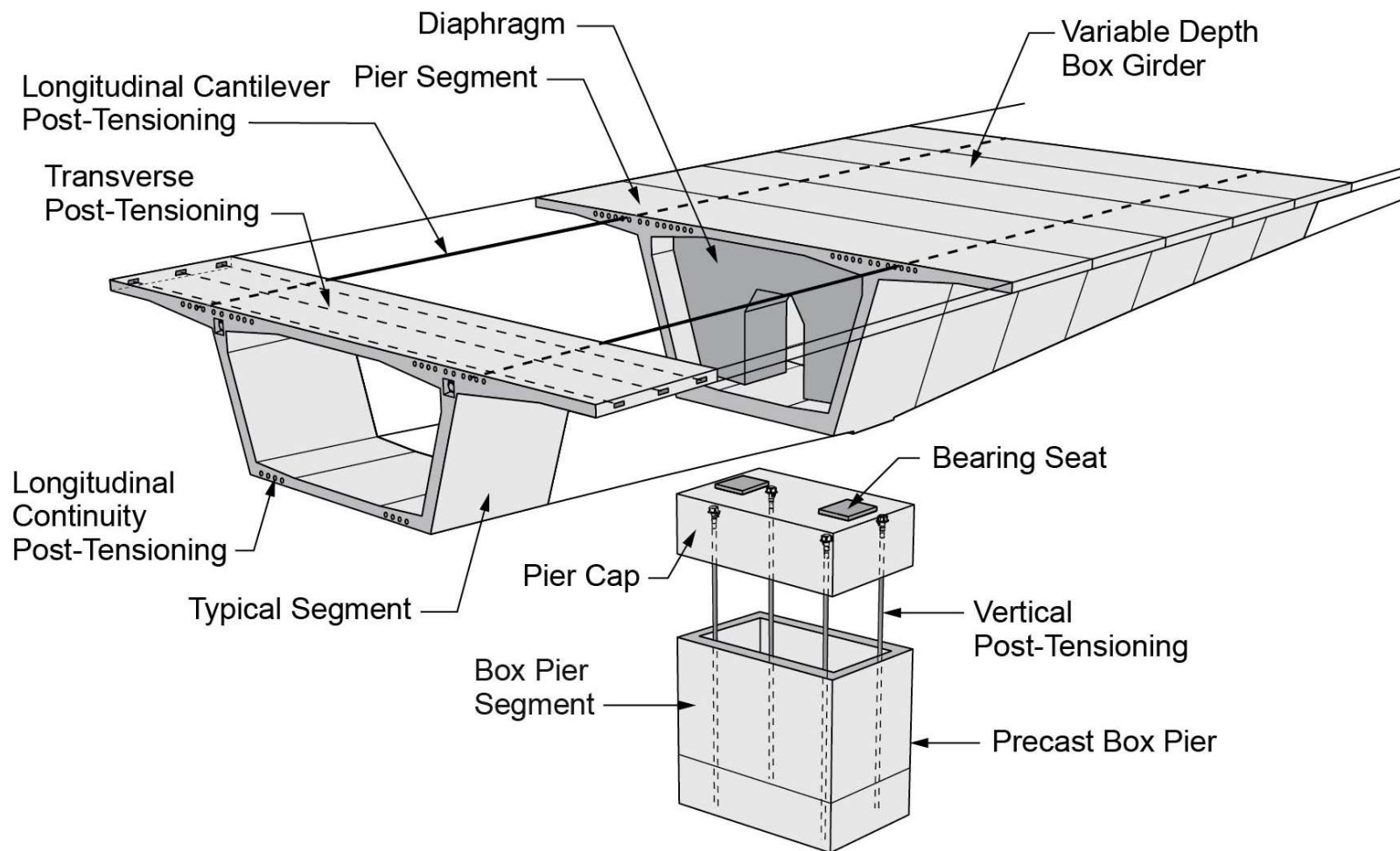
Construction Practices Handbook, 4th Edition

- Significant updates to the following chapters:
 - Chapter 7: Special Requirements for Construction of Concrete Segmental Cable-Stayed Bridges
 - Chapter 8: Segmental Substructures
 - Chapter 9: Casting Yard Planning and Set-Up



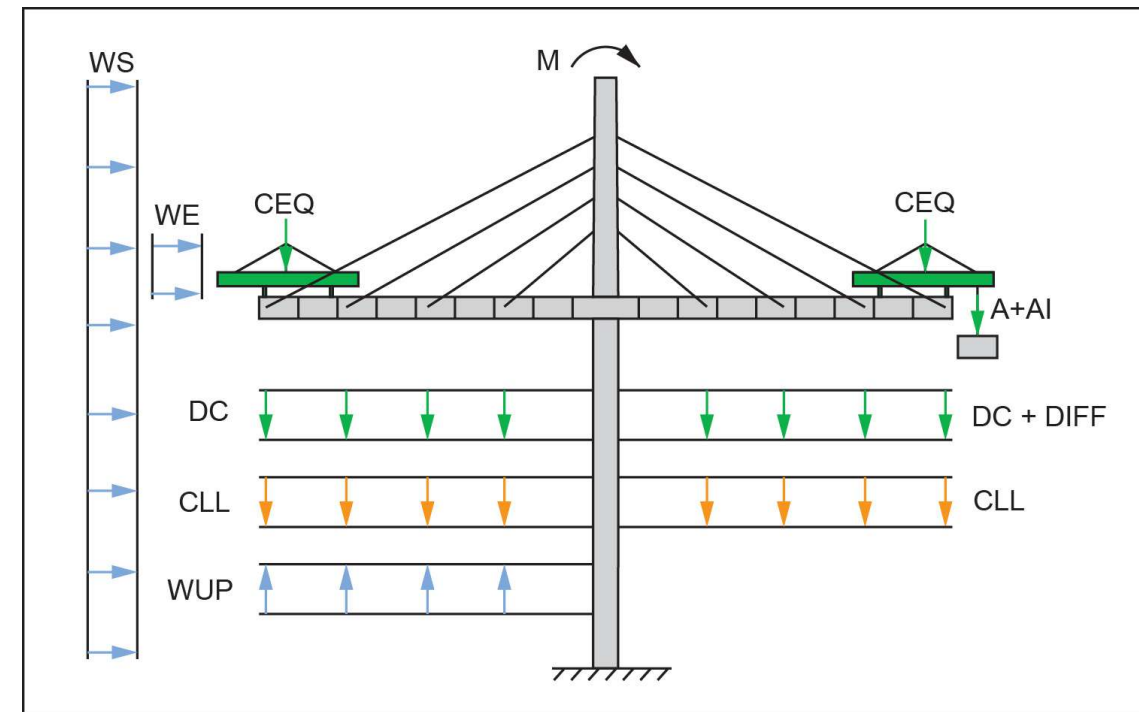
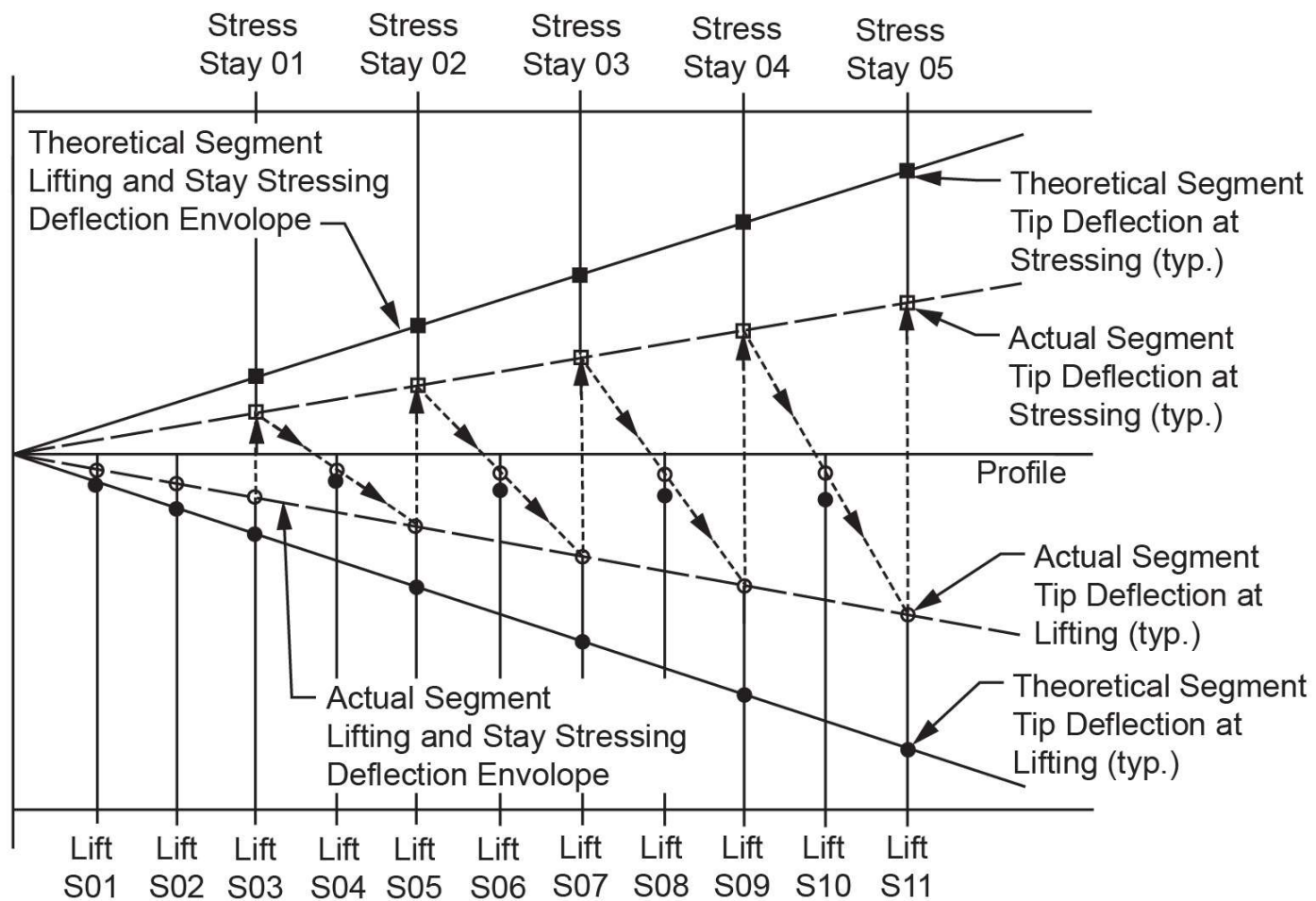
Construction Practices Handbook, 4th Edition

- Over 160 updated and/or new graphics



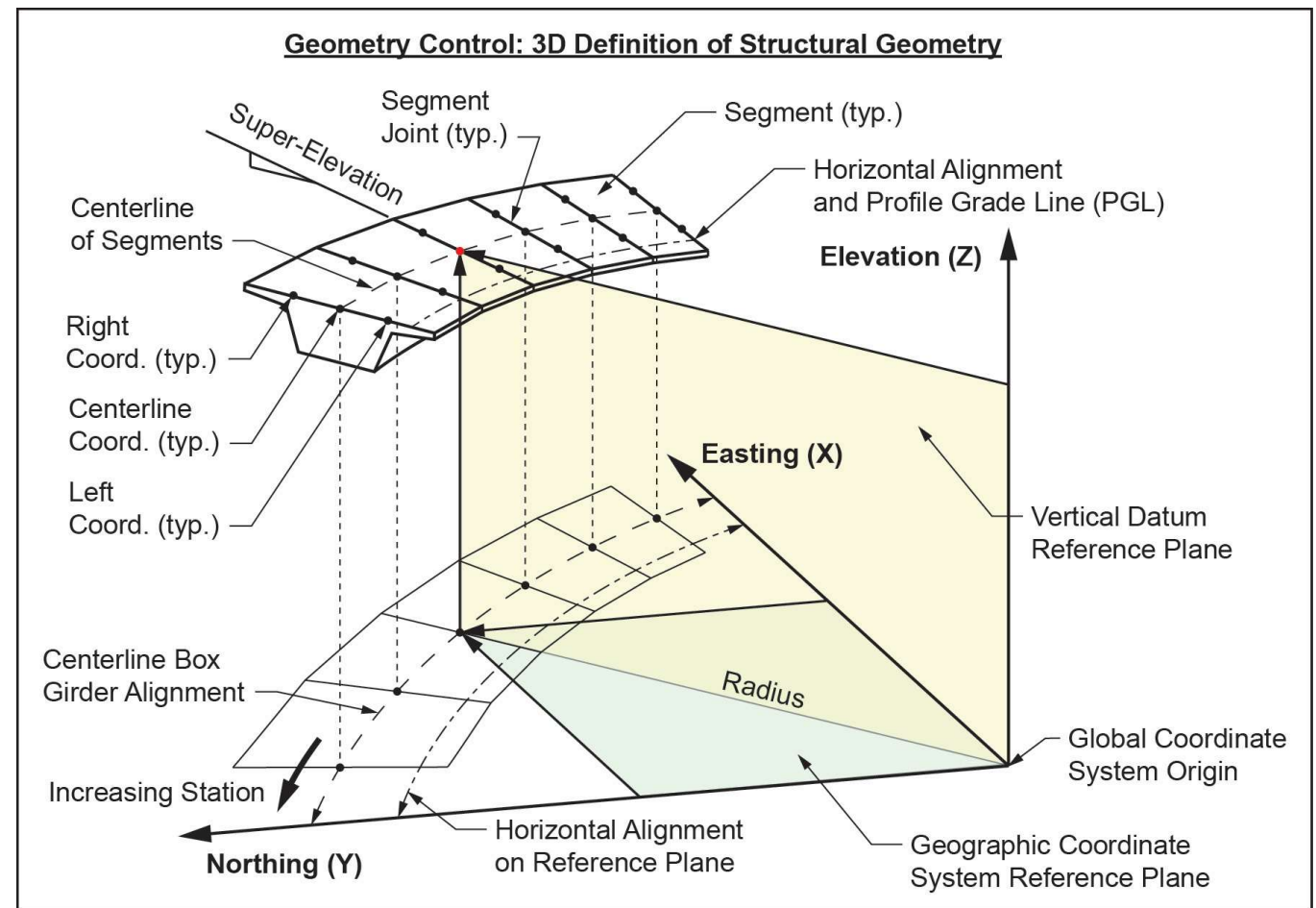
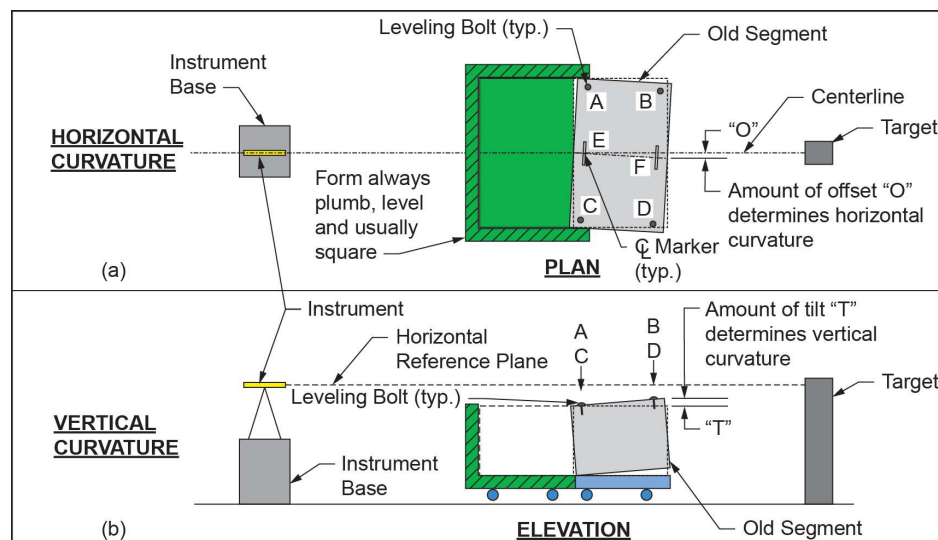
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- Particularly related to:
 - Geometry Control
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- Over one and a half days of highly technical and informative presentations
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- Registration cost includes breakfast, lunch and social hour with the experts and other seminar attendees



Construction Practices Seminar, August 13-14, 2026

- Currently over two dozen bridge owner representatives from all over the North America are registered to attend next month's seminar
- FHWA and Bridge Owners – Free Registration
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- Remain slots are **VERY** limited



Construction Practices Seminar, August 13-14, 2026

- [Asbi-assoc.org](https://asbi-assoc.org)
- Click “Learn”->”2026 Construction Practices Seminar”





Conclusion



Questions?

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