Rapid Replacement of the Hood Canal Bridge Approach Spans

Joseph Merth, P.E.
Bridge Design Engineer

3 June 2008

Washington State Department of Transportation

Overview

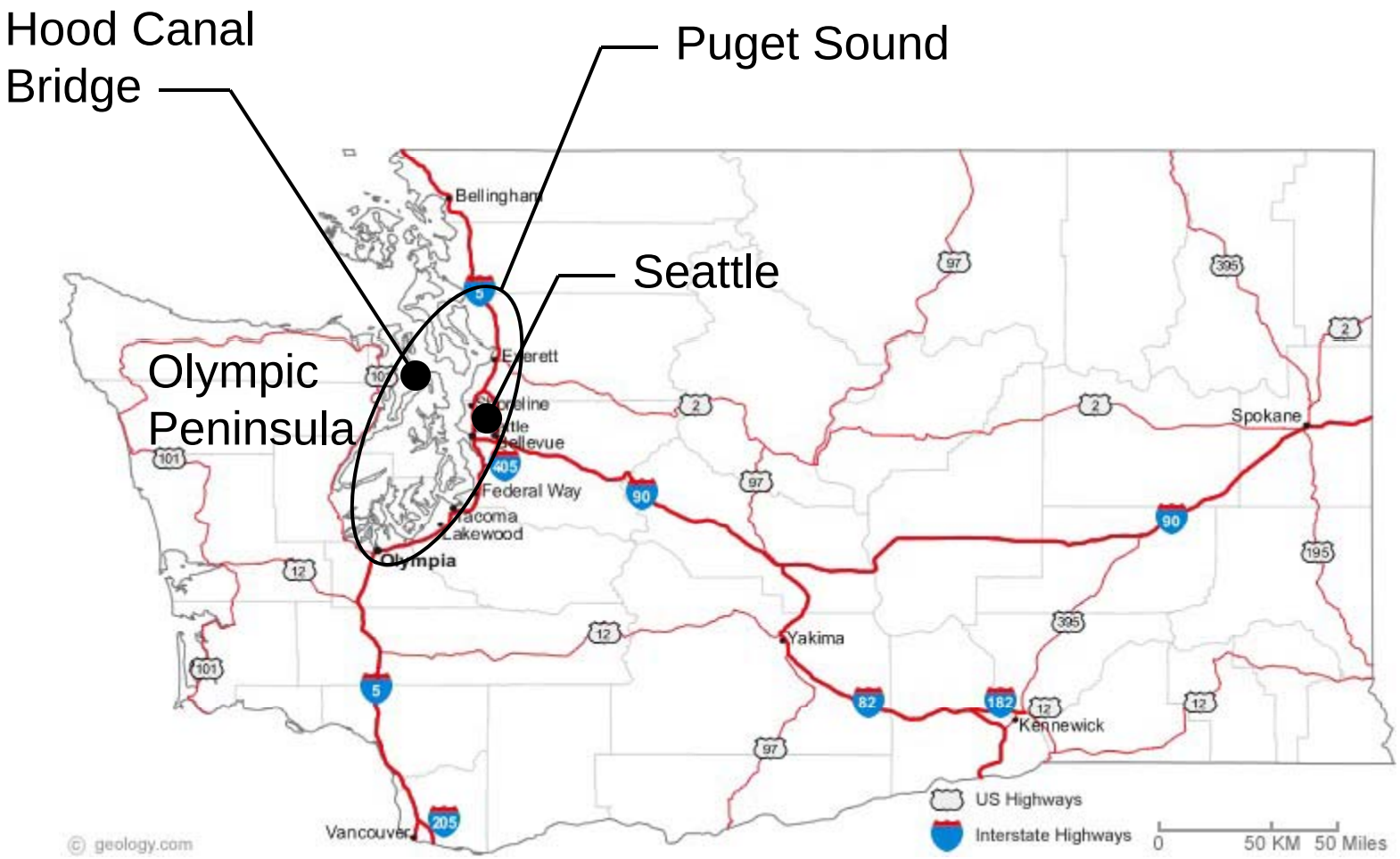
- Introduction
- Current Project
- Approach Design
- Approach Construction
- Challenges

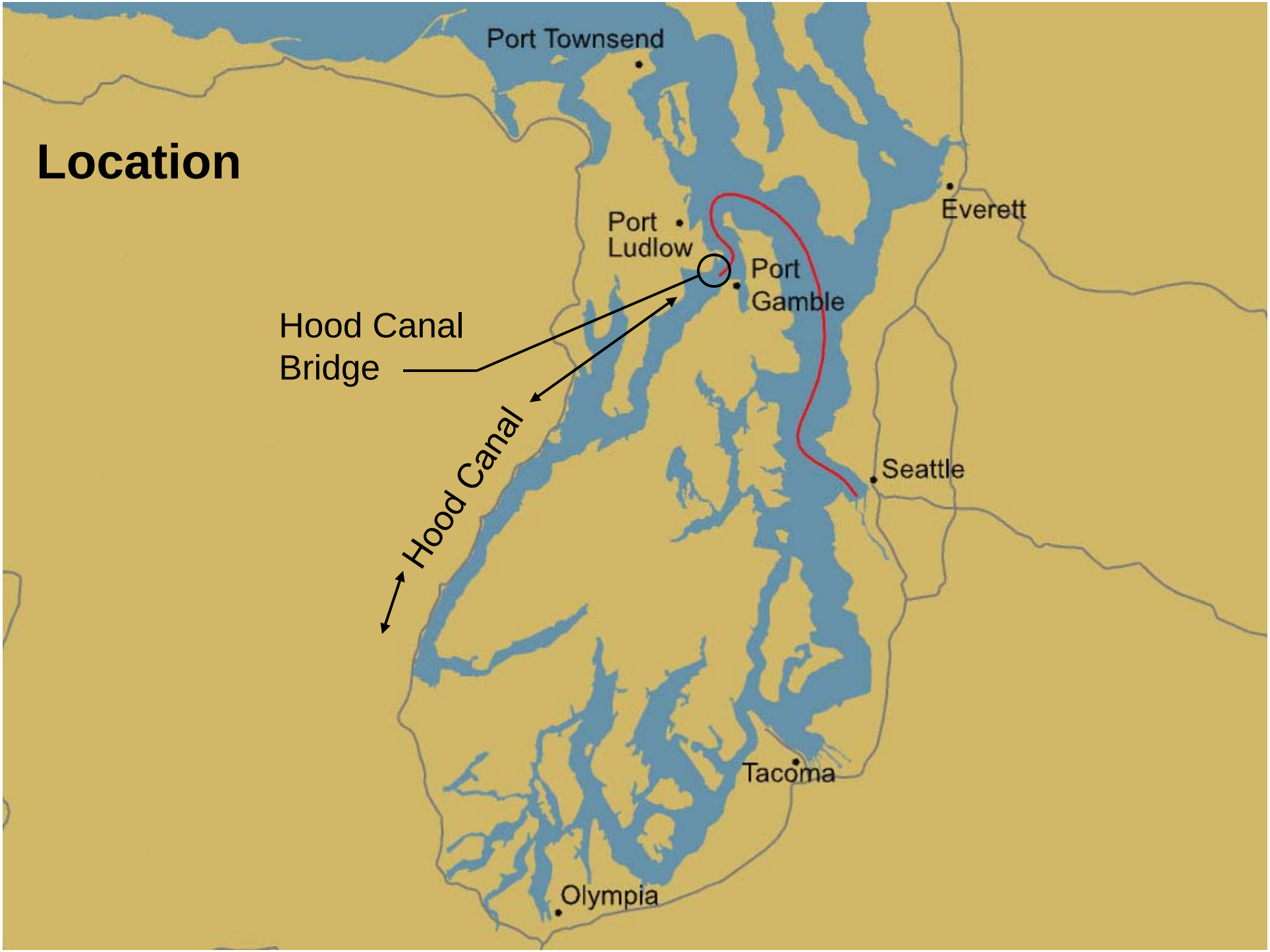
East Approach

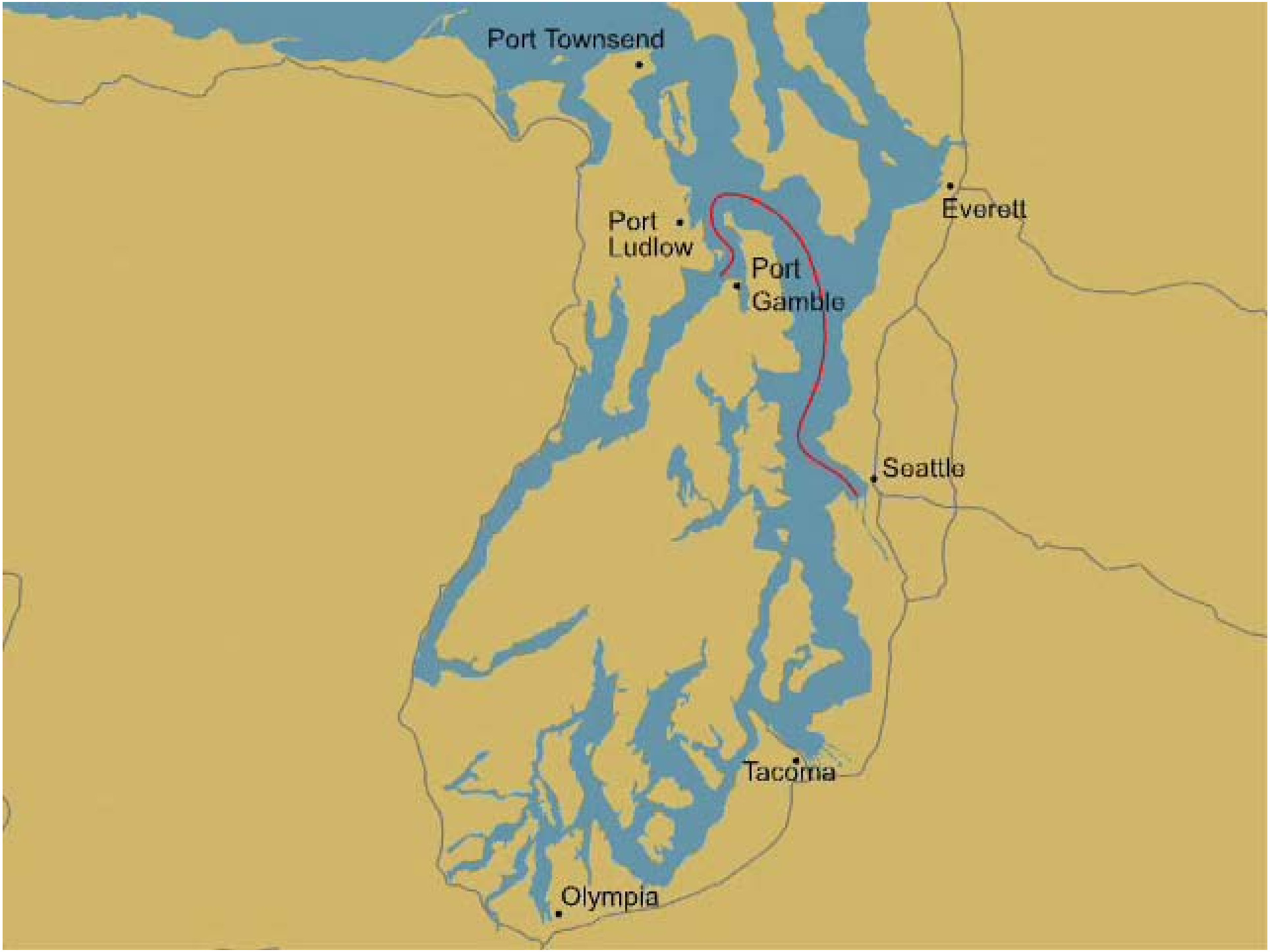
Floating Structure

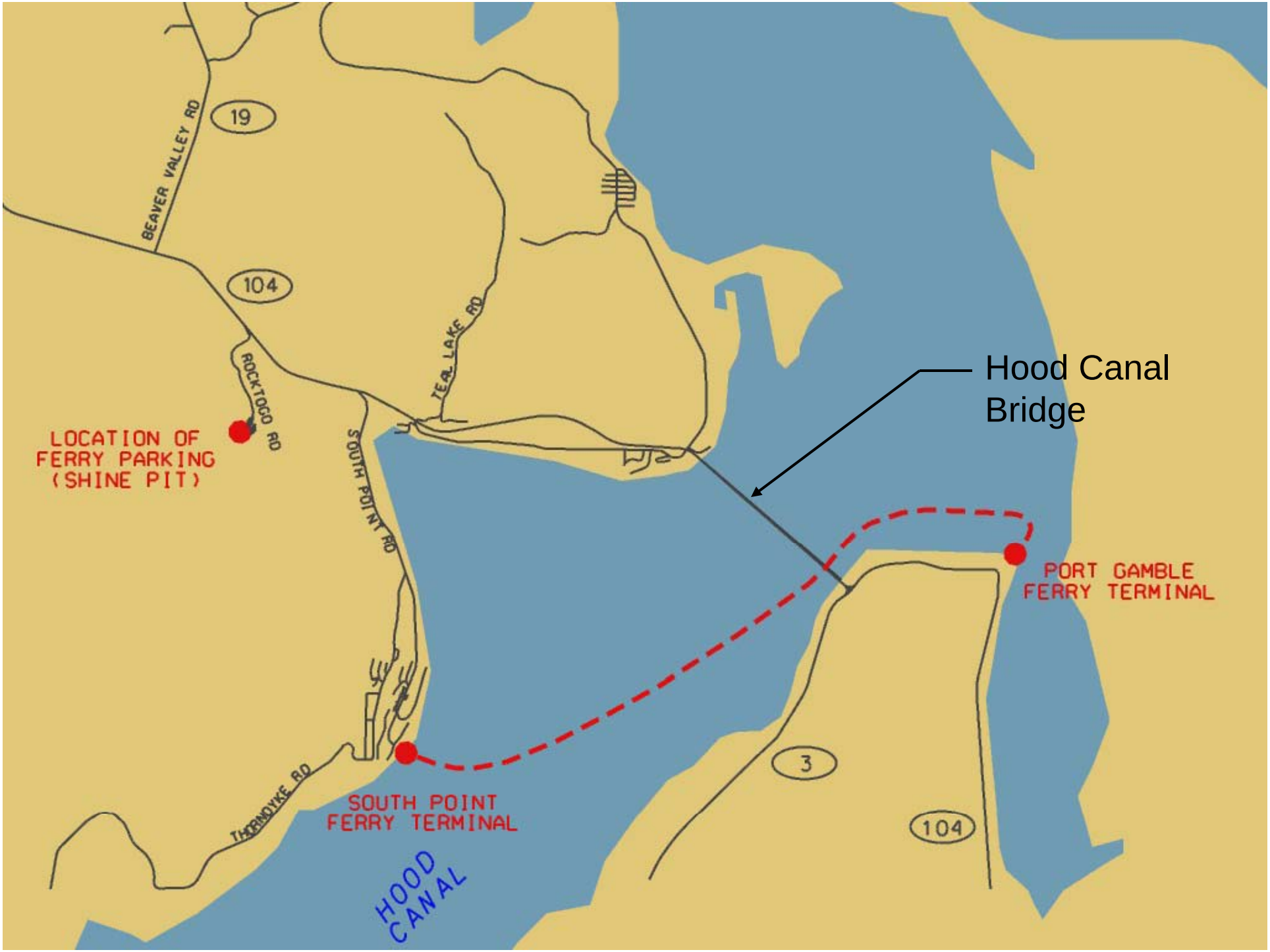
West Approach

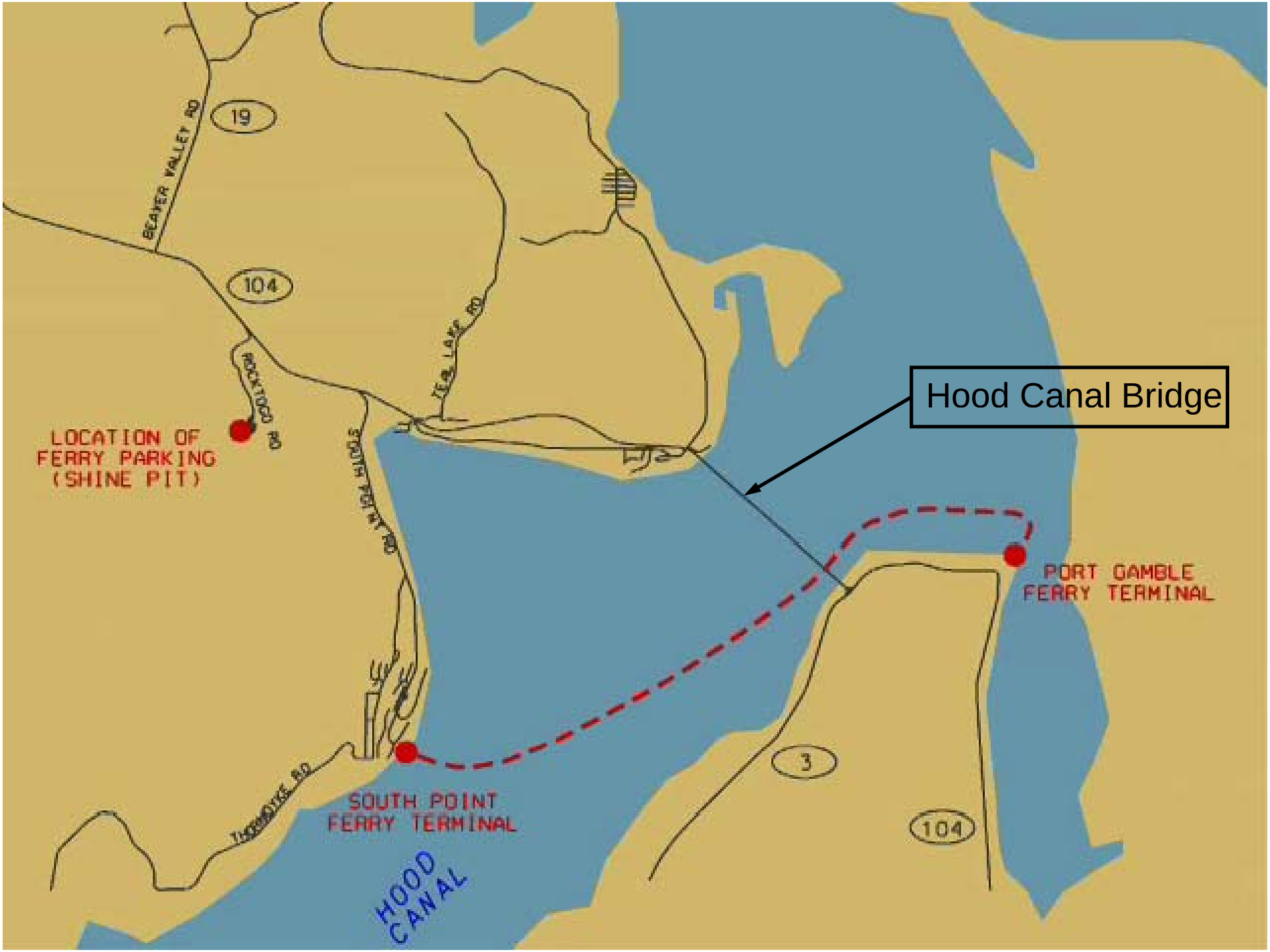
Location

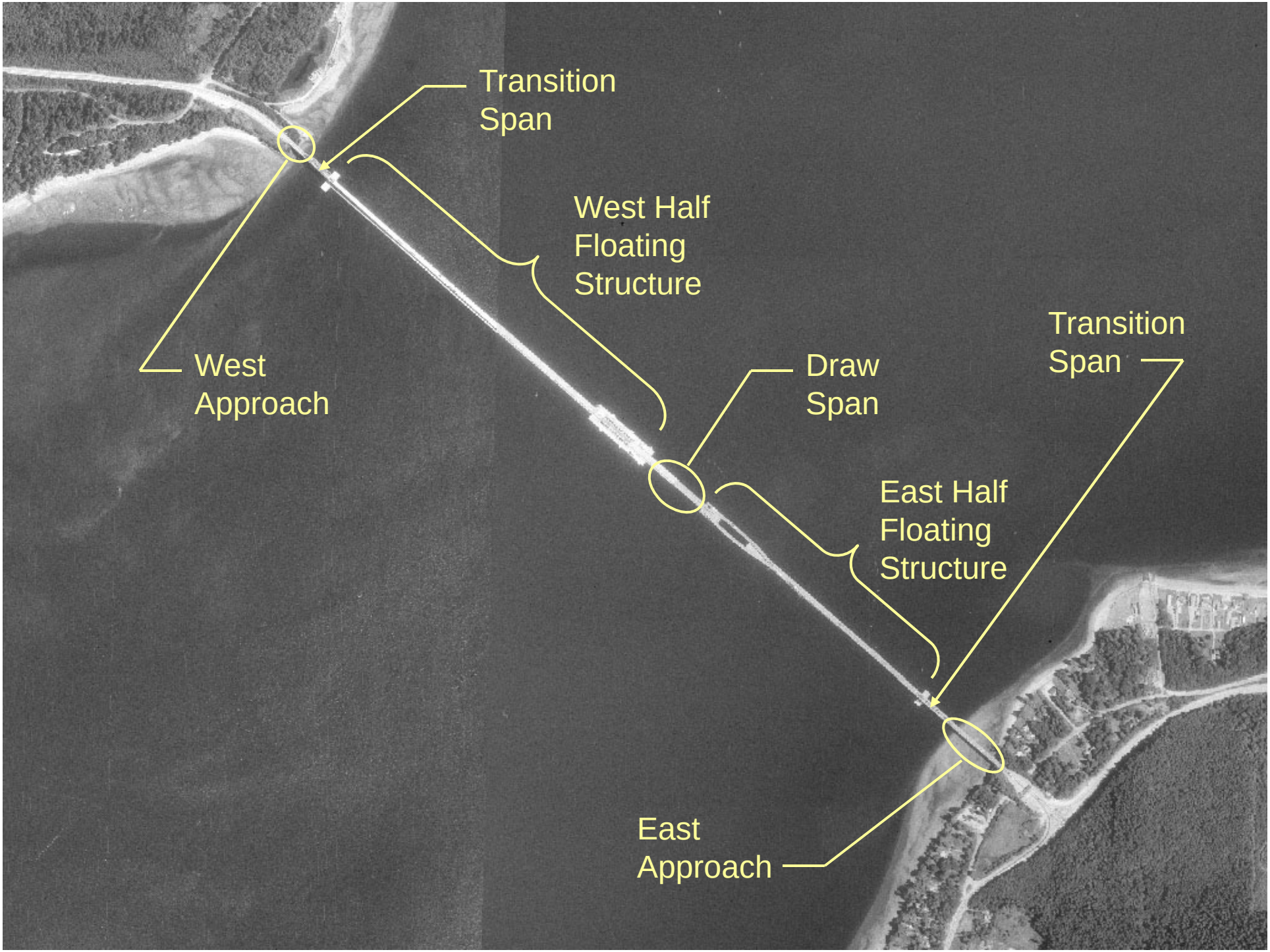

Hood Canal Bridge
Puget Sound
Seattle
Olympic Peninsula
Bellingham
Everett
Bellevue
Federal Way
Tacoma
Lakewood
Olympia
Yakima
Kennewick
Spokane
Vancouver
US Highways
Interstate Highways
0
50 KM 50 Miles
© geology.com


Location
Port Townsend
Port Ludlow
Port Gamble
Everett
Hood Canal Bridge
Hood Canal
Seattle
Tacoma
Olympia


Port Townsend
Port Ludlow
Port Gamble
Everett
Seattle
Tacoma
Olympia


BEAVER VALLEY RD
19
104
ROCKTOGO RD
TEAL LAKE RD
SOUTH POINT RD
LOCATION OF
FERRY PARKING
(SHINE PIT)
Hood Canal
Bridge
PORT GAMBLE
FERRY TERMINAL
3
104
THORNDYKE RD
SOUTH POINT
FERRY TERMINAL
HOOD
CANAL


Hood Canal Bridge
LOCATION OF FERRY PARKING (SHINE PIT)
PORT GAMBLE FERRY TERMINAL
SOUTH POINT FERRY TERMINAL
HOOD CANAL
BEAVER VALLEY RD
19
104
ROCKTOGO RD
SOUTH POINT RD
3
104

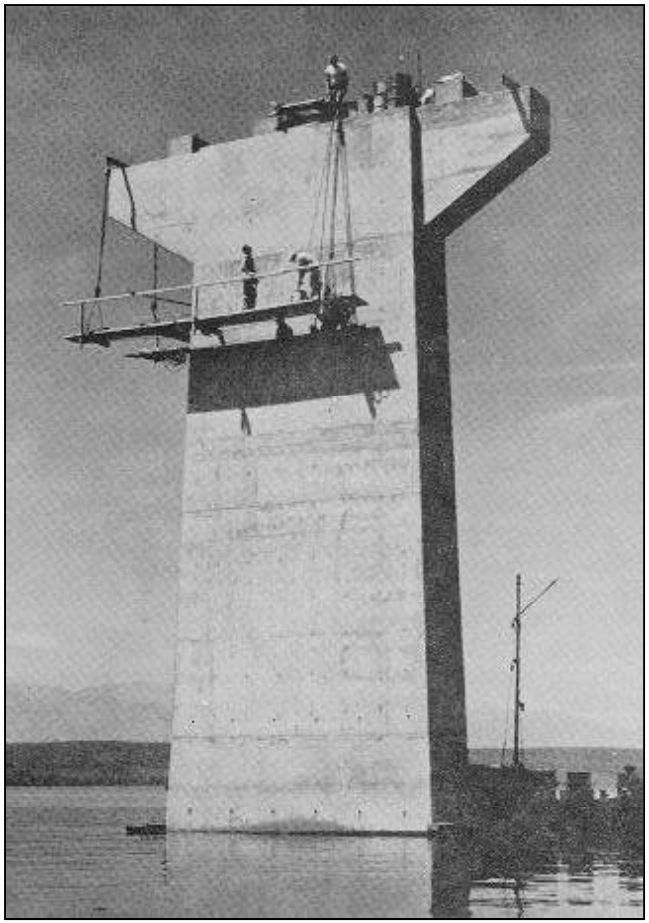

Transition Span
West Half Floating Structure
West Approach
Draw Span
Transition Span
East Half Floating Structure
East Approach

Bridge Facts

- Length – 7869 feet
  (Longest floating bridge over salt water)
- Floating portion – 6530 feet
- Max water depth – 340 feet
- Tidal Variation – 16.5 feet
- Center draw span opening – 600 feet

Bridge History

- Original Construction – January 1958
- Open to traffic – 12 August 1961



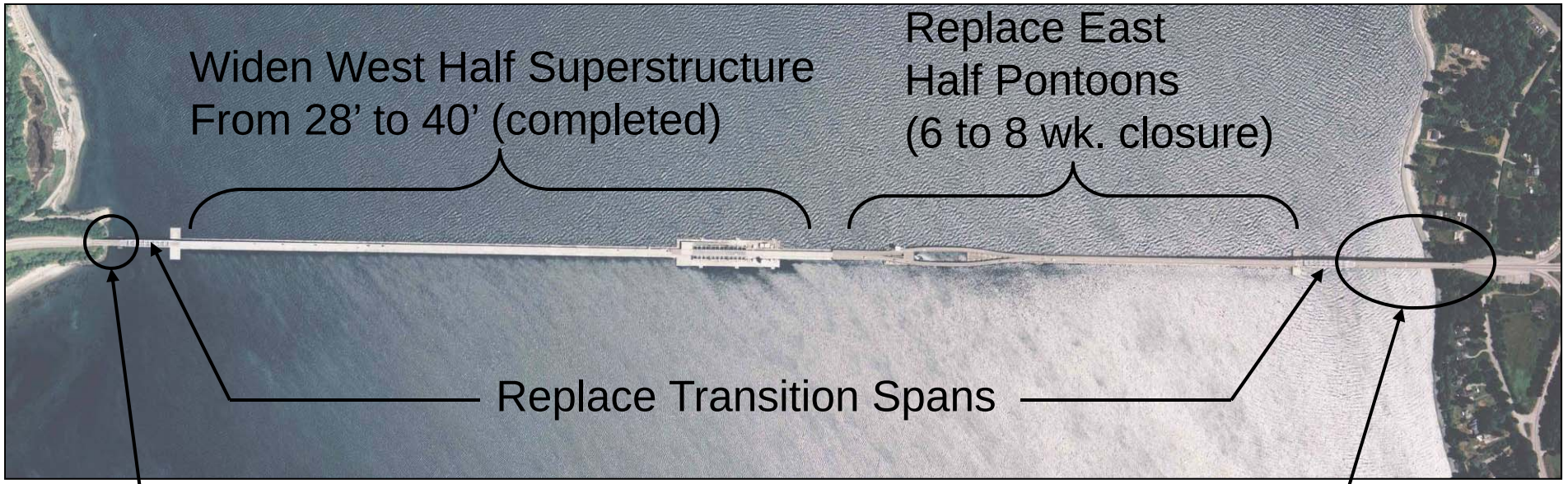
West Half Fails

- February 13, 1979
- Sustained winds of 85mph
- 120mph gusts

West Half Replacement

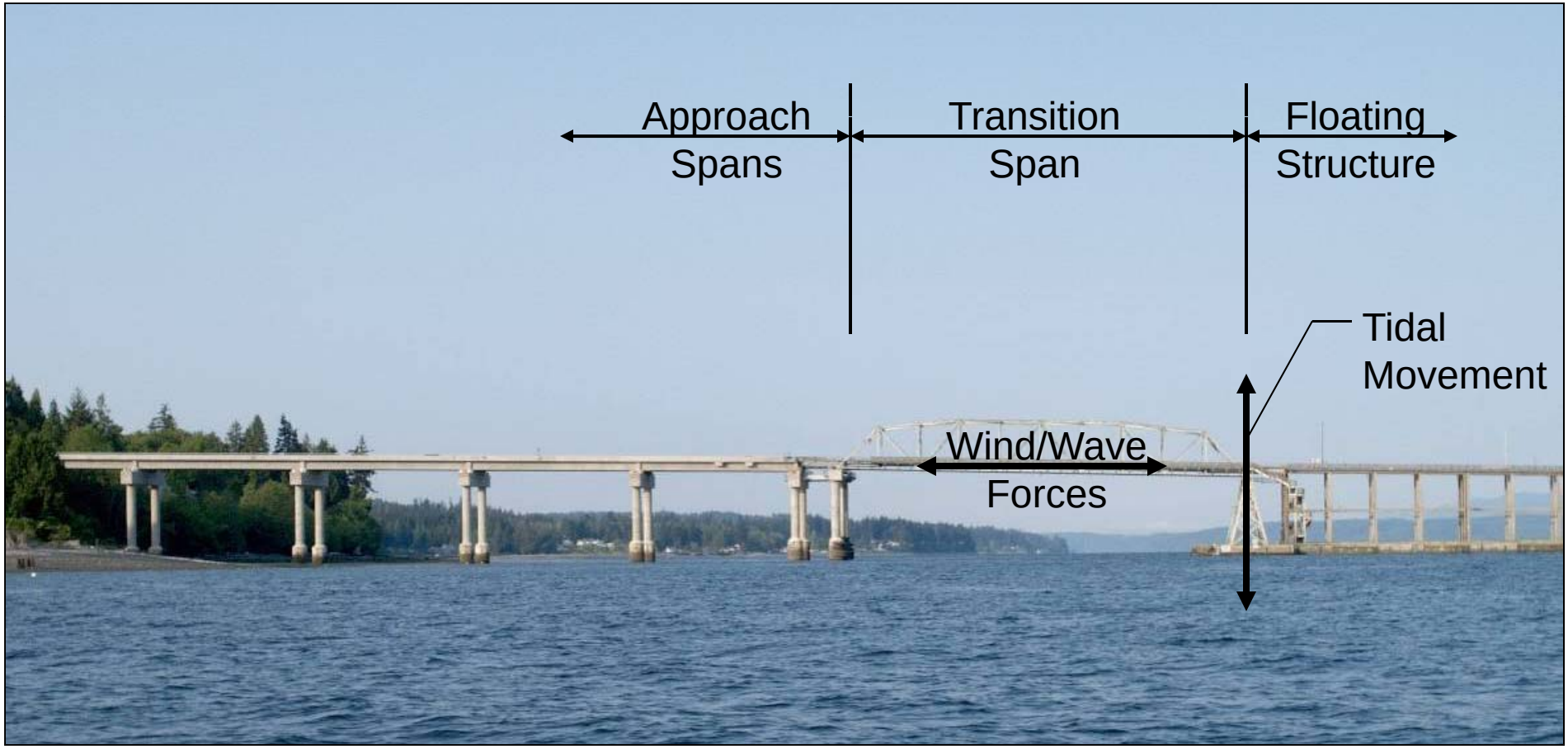
- Reopened Oct. 25th, 1982
- Post-tensioned pontoons
- Increased anchor size

Current Project



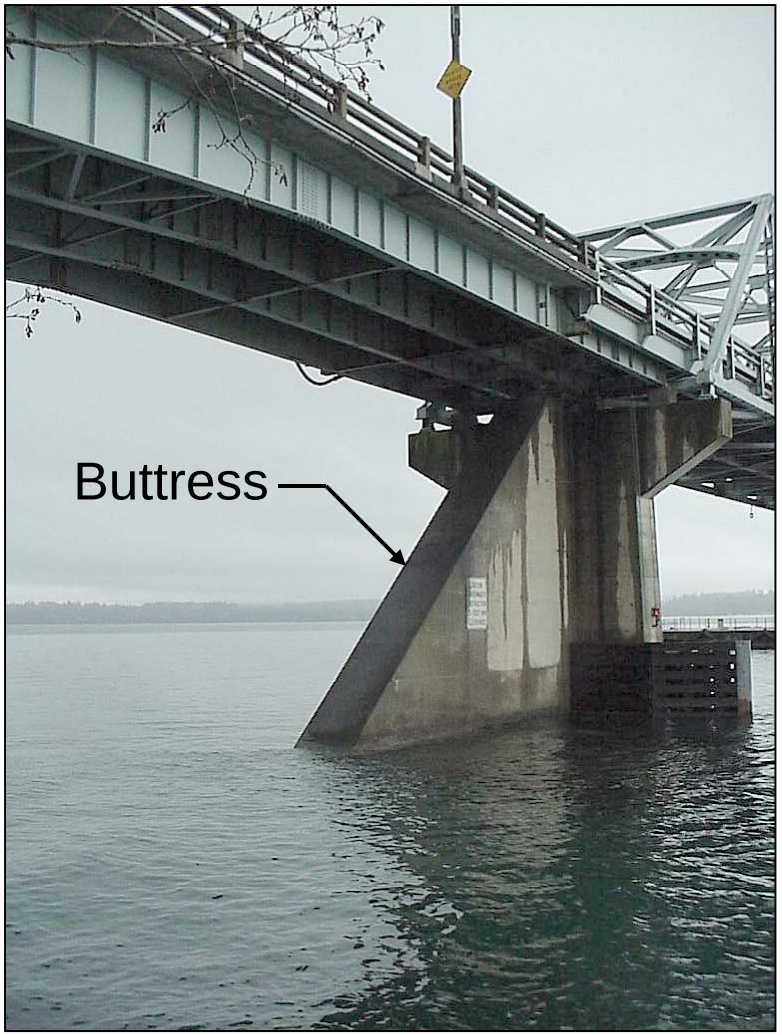
Approaches

- Provide fixed link from shore to floating structure
- Help resist longitudinal wind and wave forces from the floating structure



Original West Approach

- 2 – span haunched steel PL Girder
- 190’ length
- Buttress added for West half replacement



Original East Approach

- 6 – span haunched steel PL Girder
- 643’ length
- Wind/Wave forces – Pier 4

Approach Retrofit

- Original Retrofit Requirement
  - Deck Replacement
  - Seismic Retrofit
  - Pier 4 retrofit (add buttress wall)
- Required 6-8 week closure

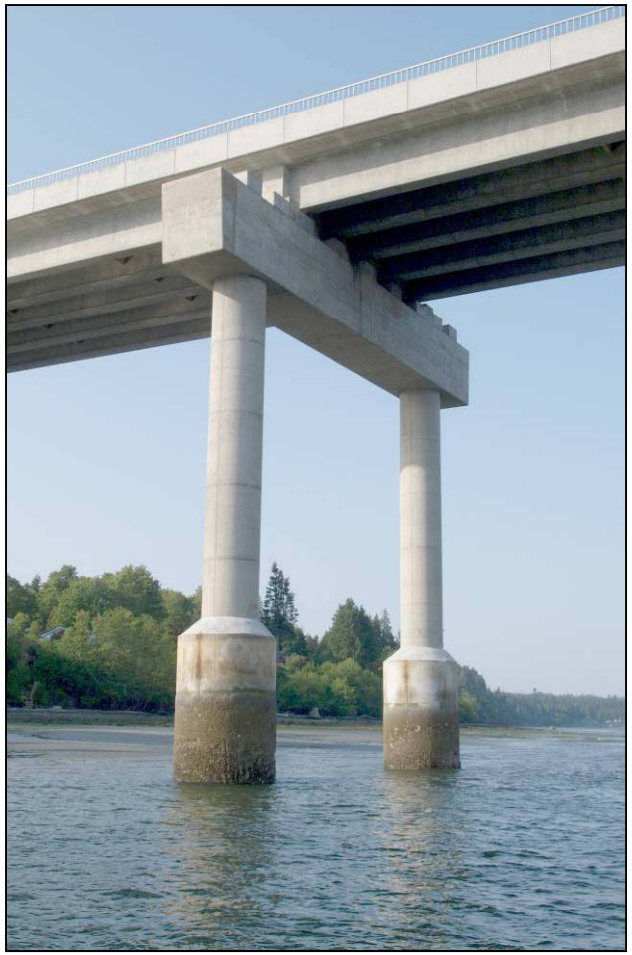
West

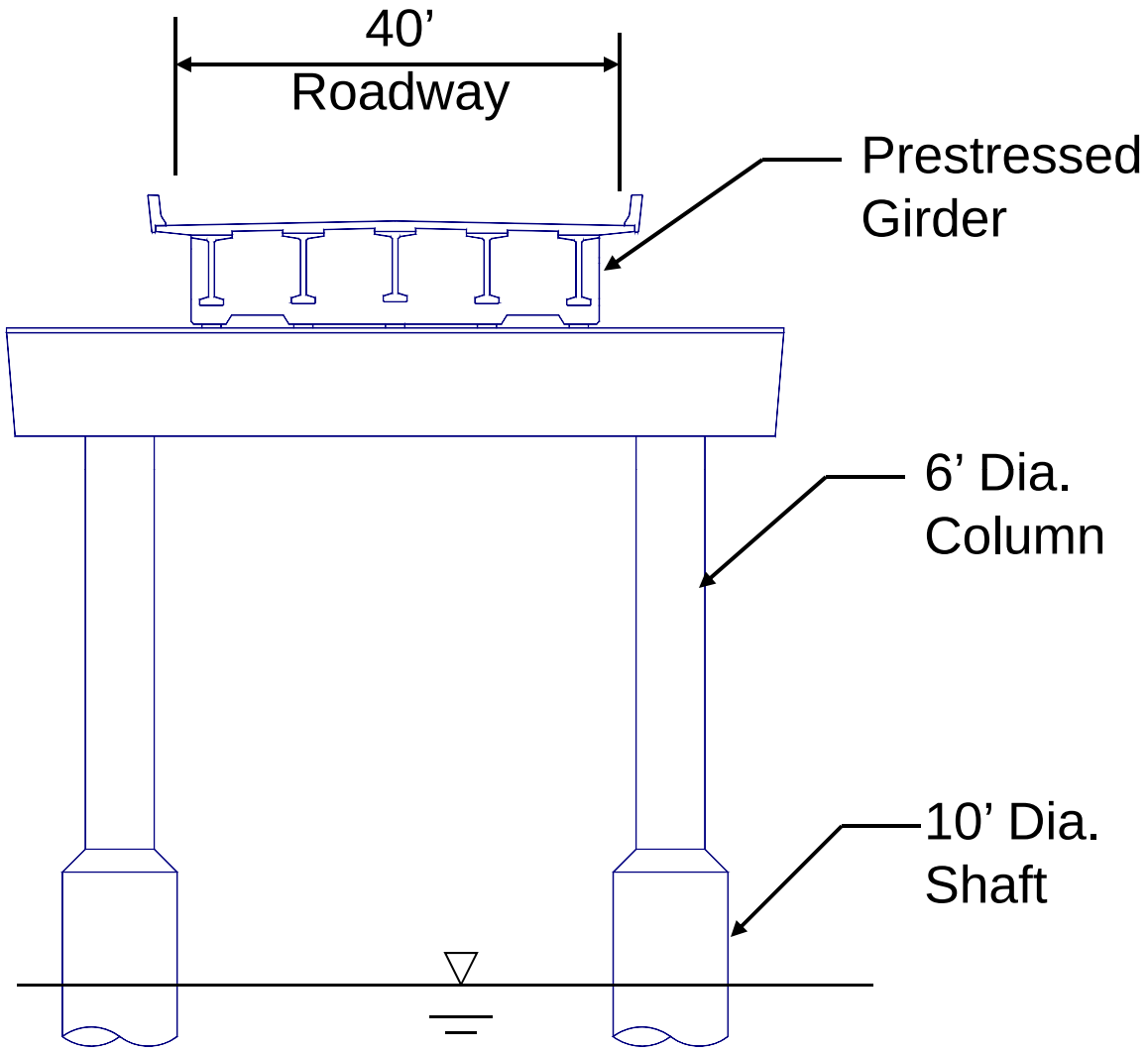
East

Approach Replacement

- Replace entire approaches (superstructure/substructure)
- Build to current standards – 40’ roadway, seismic
- Ability to widen to 4 lanes (60’) in the future

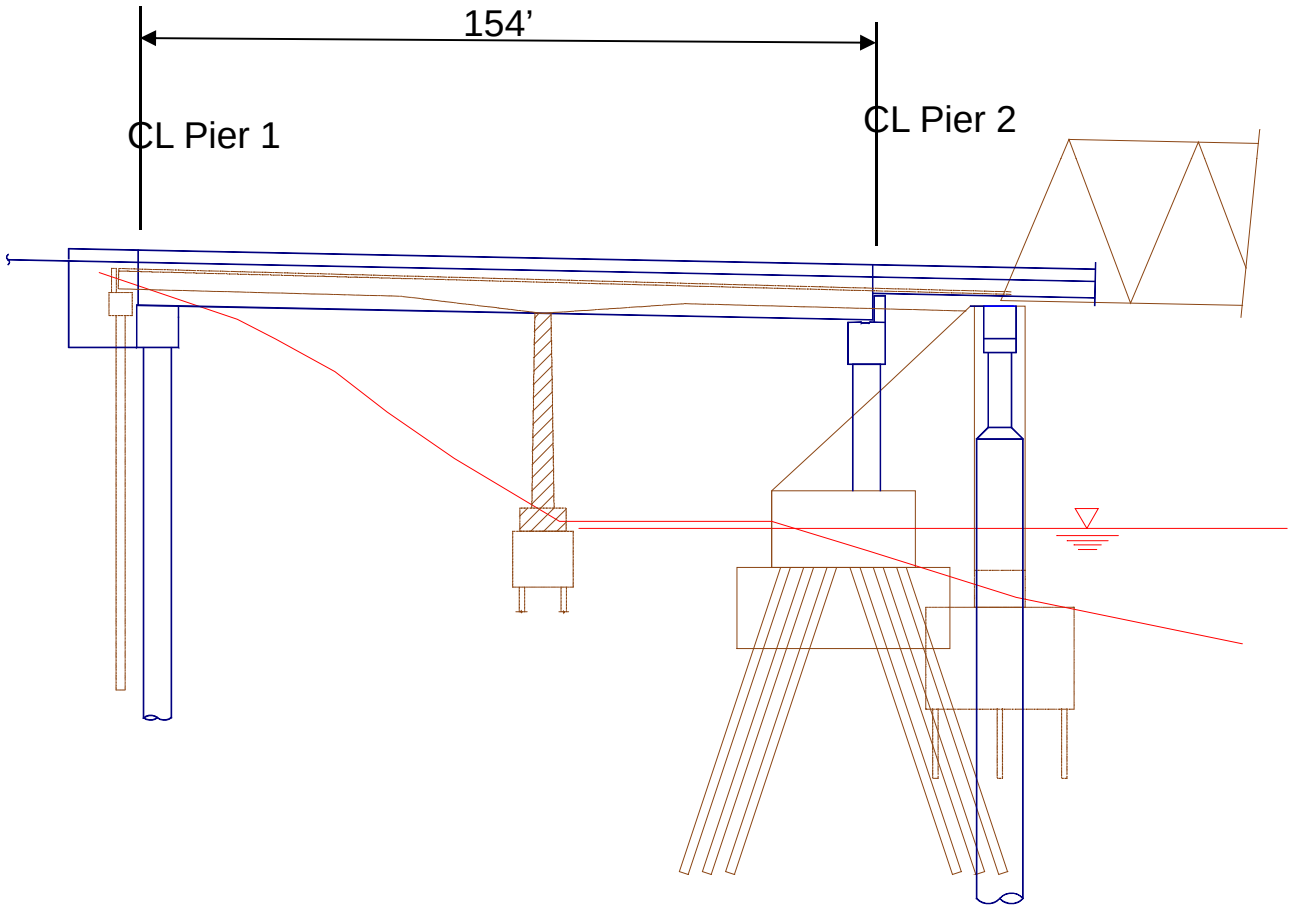
Typical Section





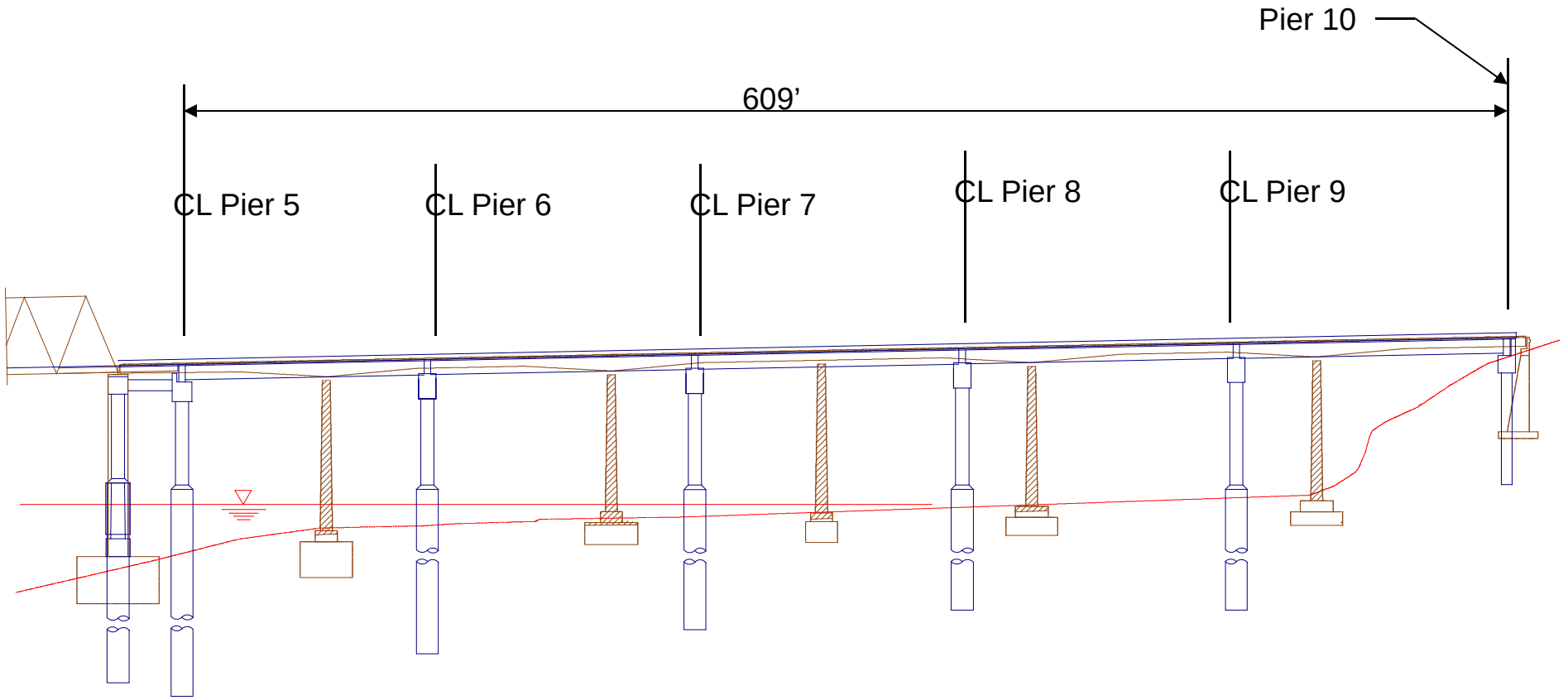
West Approach Elevation

- 1 span (W83G Girders)
- 154’ total length



East Approach Elevation

- 5 spans (W74G Girders)
- 609’ total length

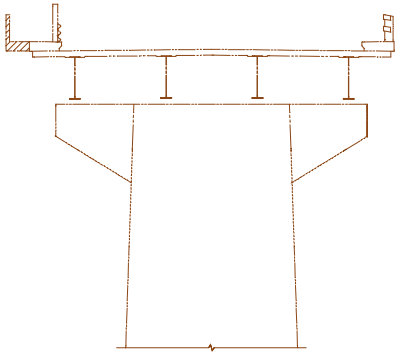


Replacement Challenges

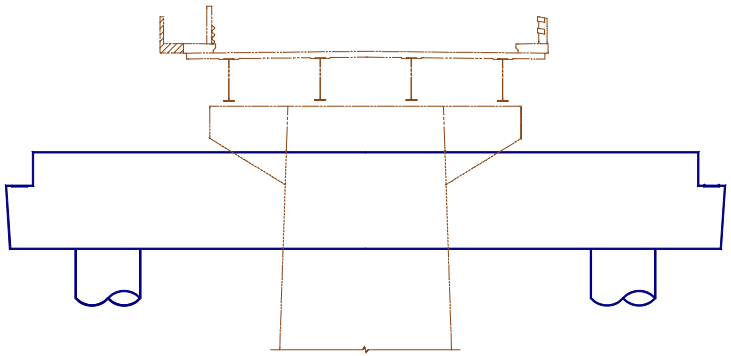
- Limited closure – extended weekend
  - Construct superstructure adjacent to existing approach
- Distribute wind/wave forces into East Approach

Rolling Scheme

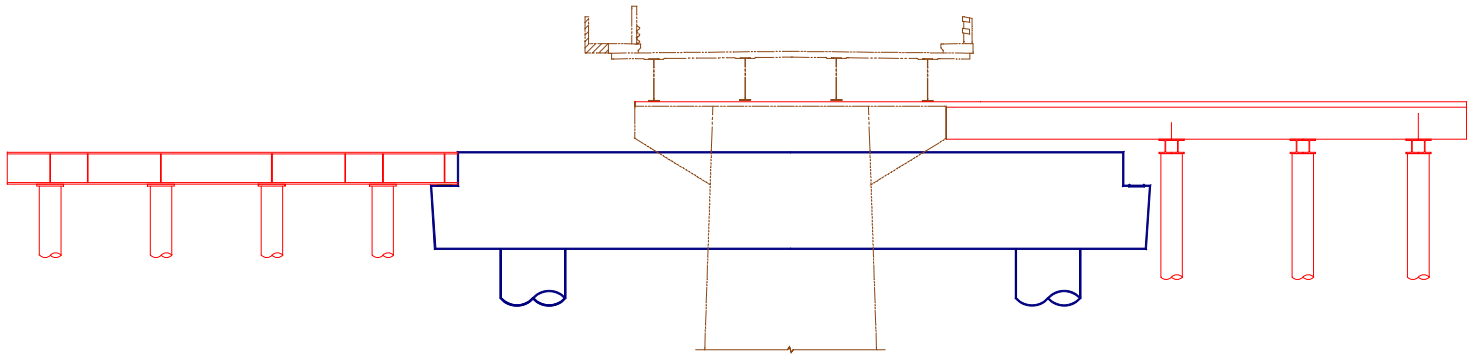
Rolling Scheme
Prior to Rollover



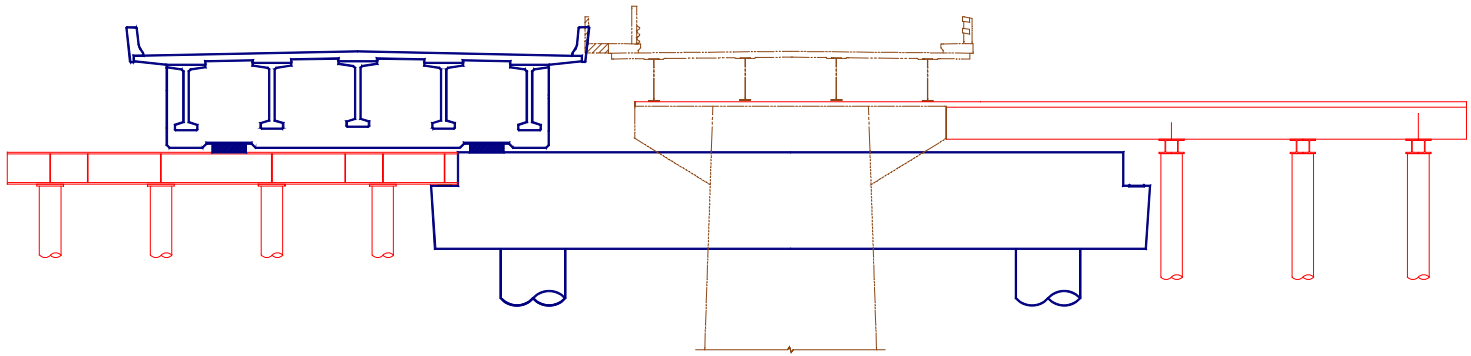
Rolling Scheme
Prior to Rollover



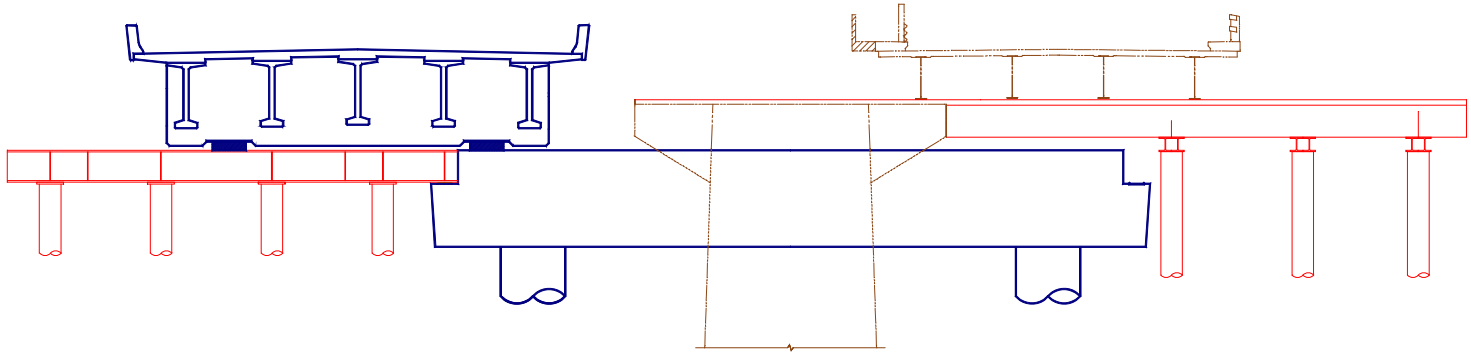
Rolling Scheme
Prior to Rollover



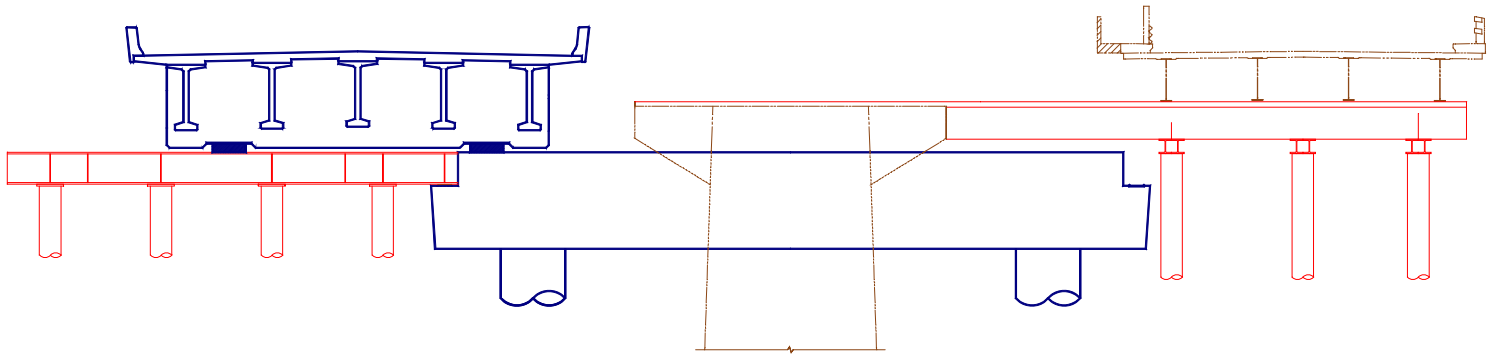
Rolling Scheme
Prior to Rollover



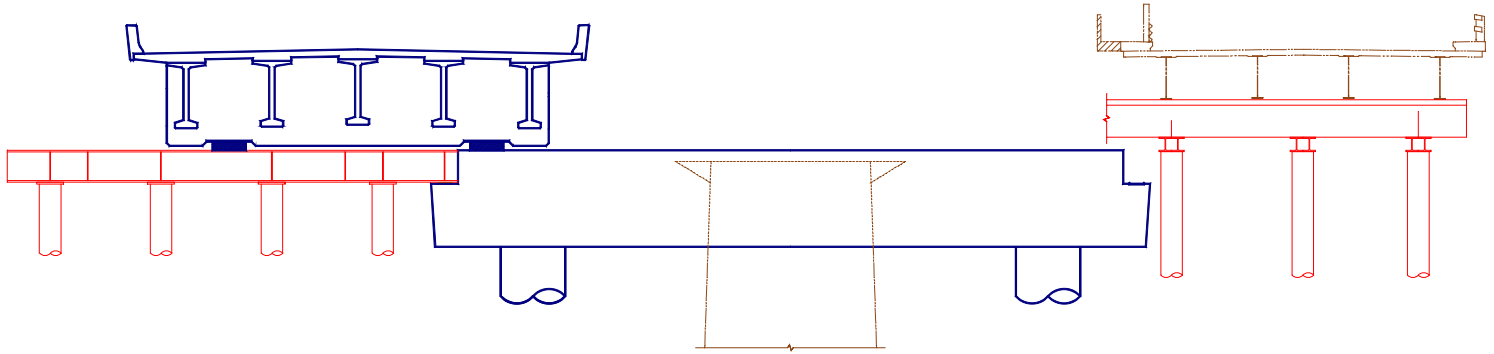
Rolling Scheme
During Rollover



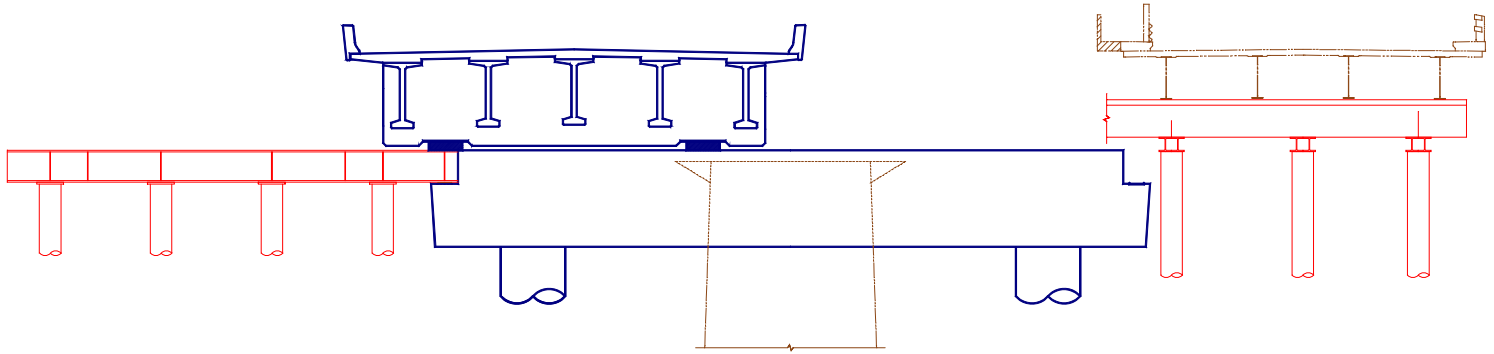
Rolling Scheme
During Rollover



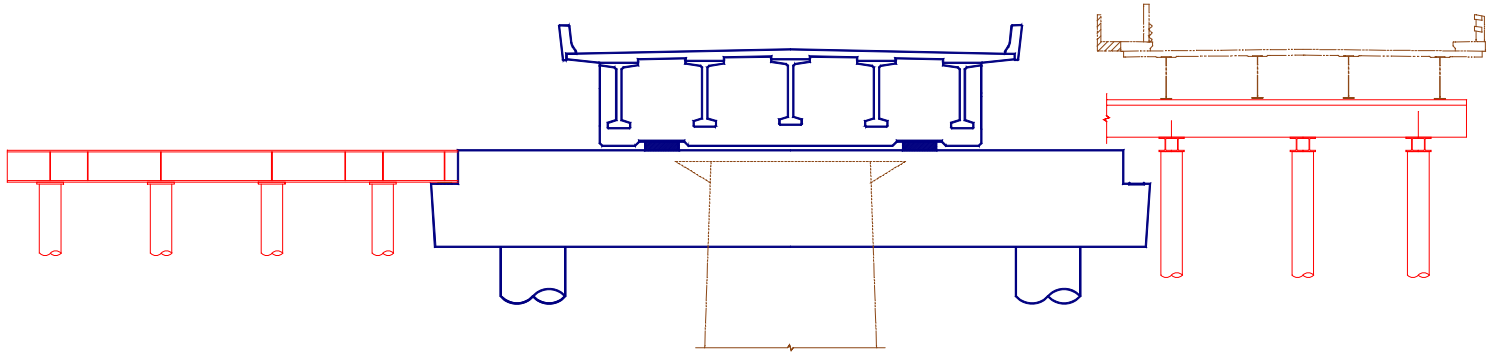
Rolling Scheme
During Rollover



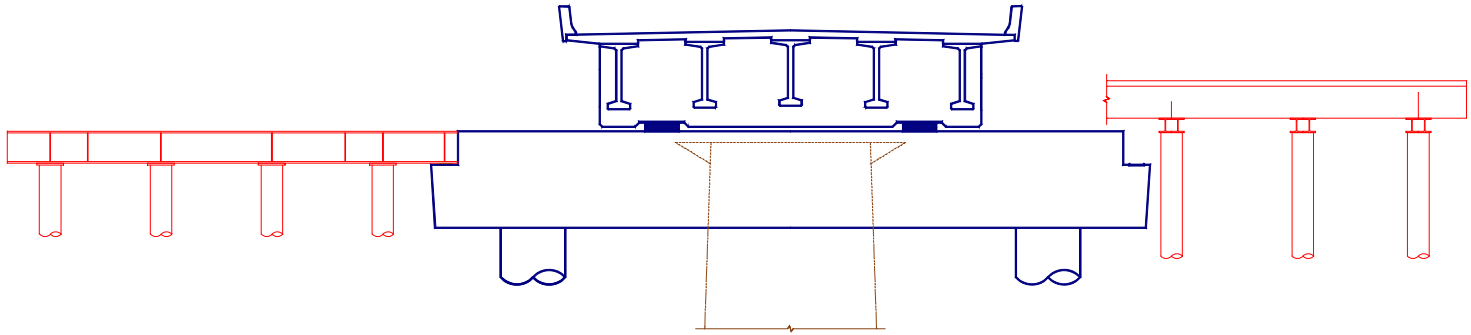
Rolling Scheme
During Rollover



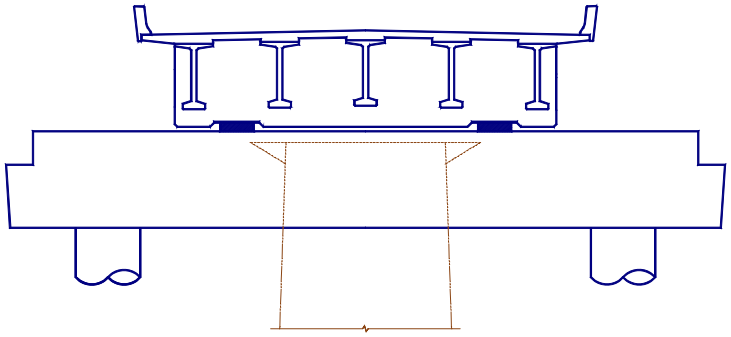
Rolling Scheme
During Rollover



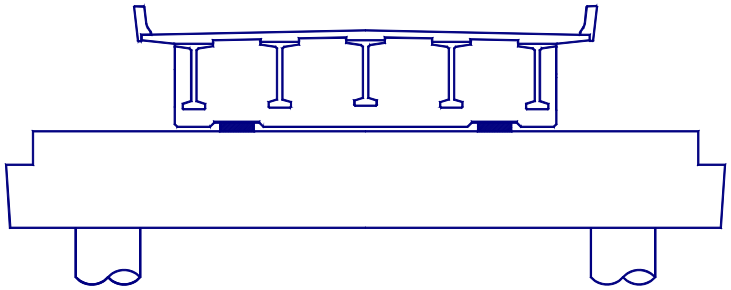
Rolling Scheme
After Rollover



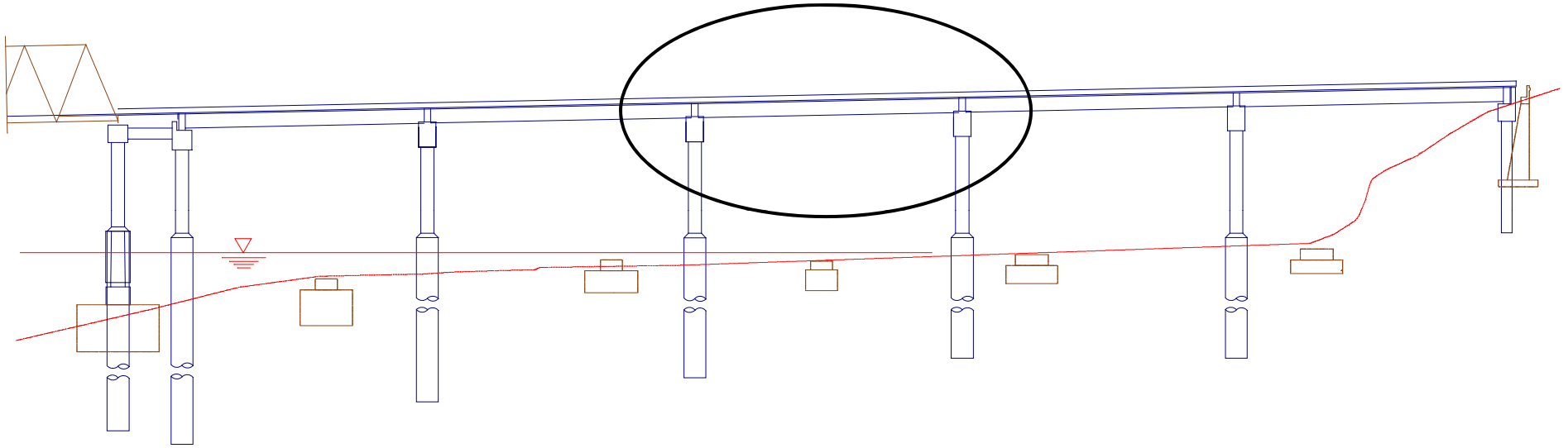
Rolling Scheme
After Rollover



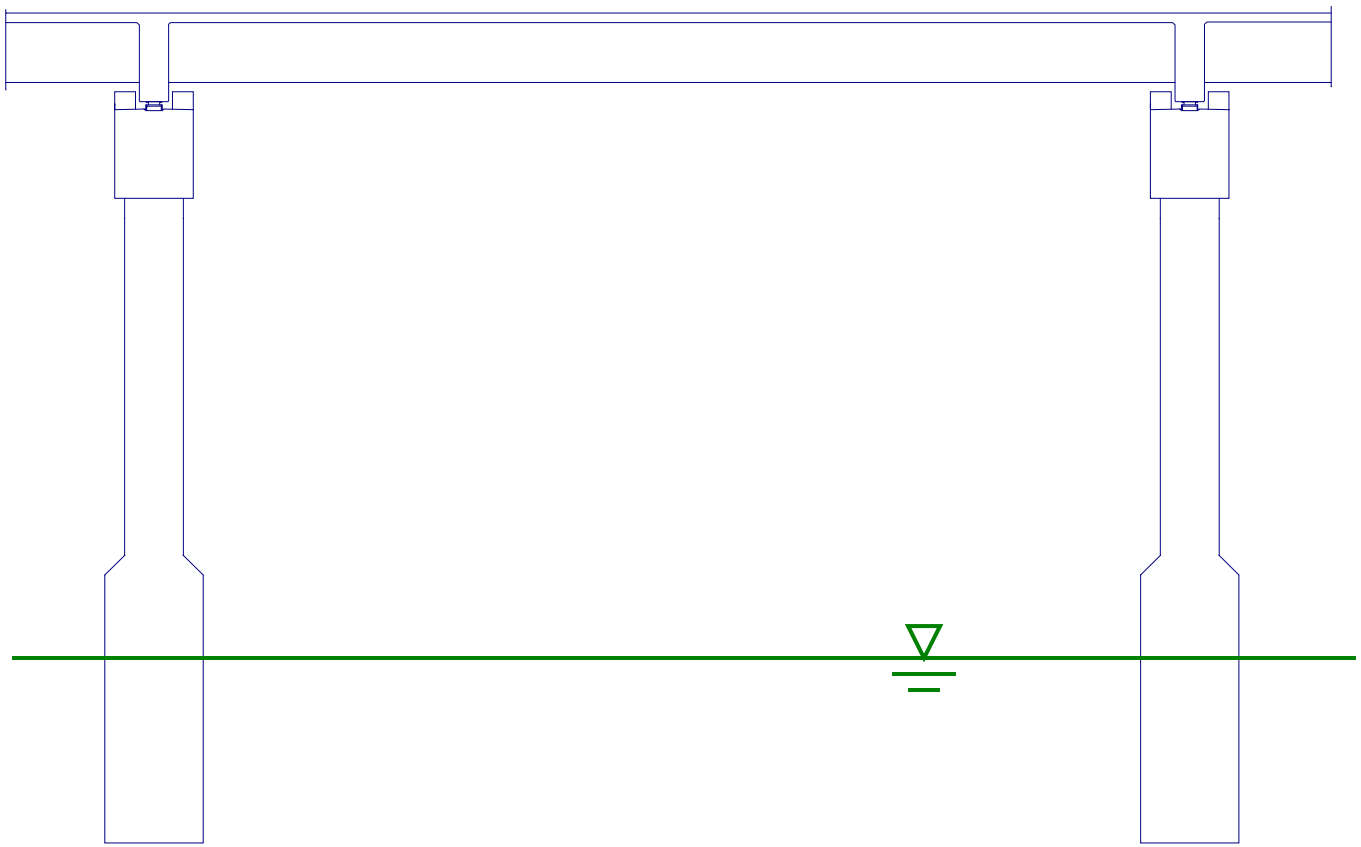
Rolling Scheme
After Rollover



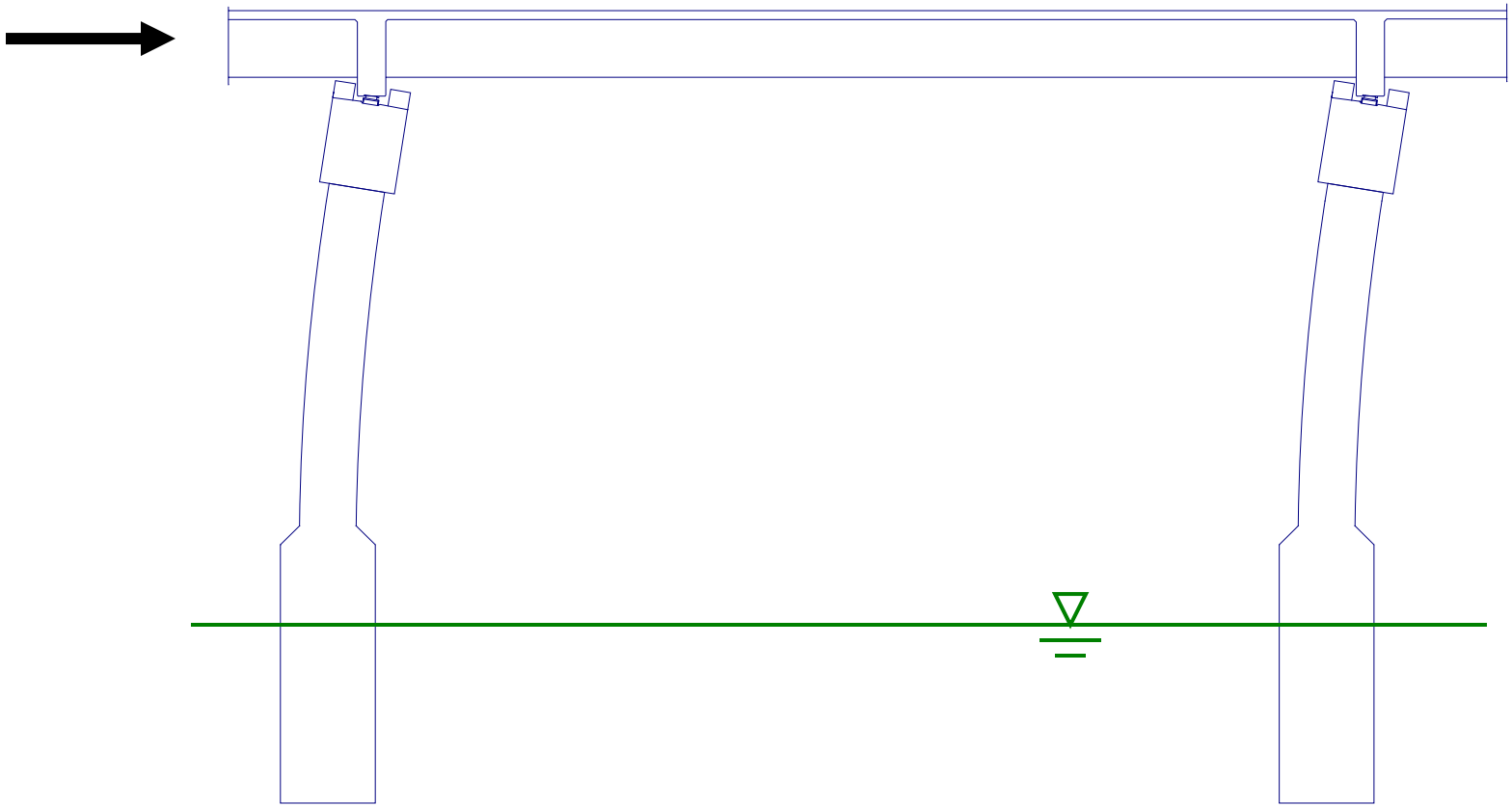
Wind/Wave Forces



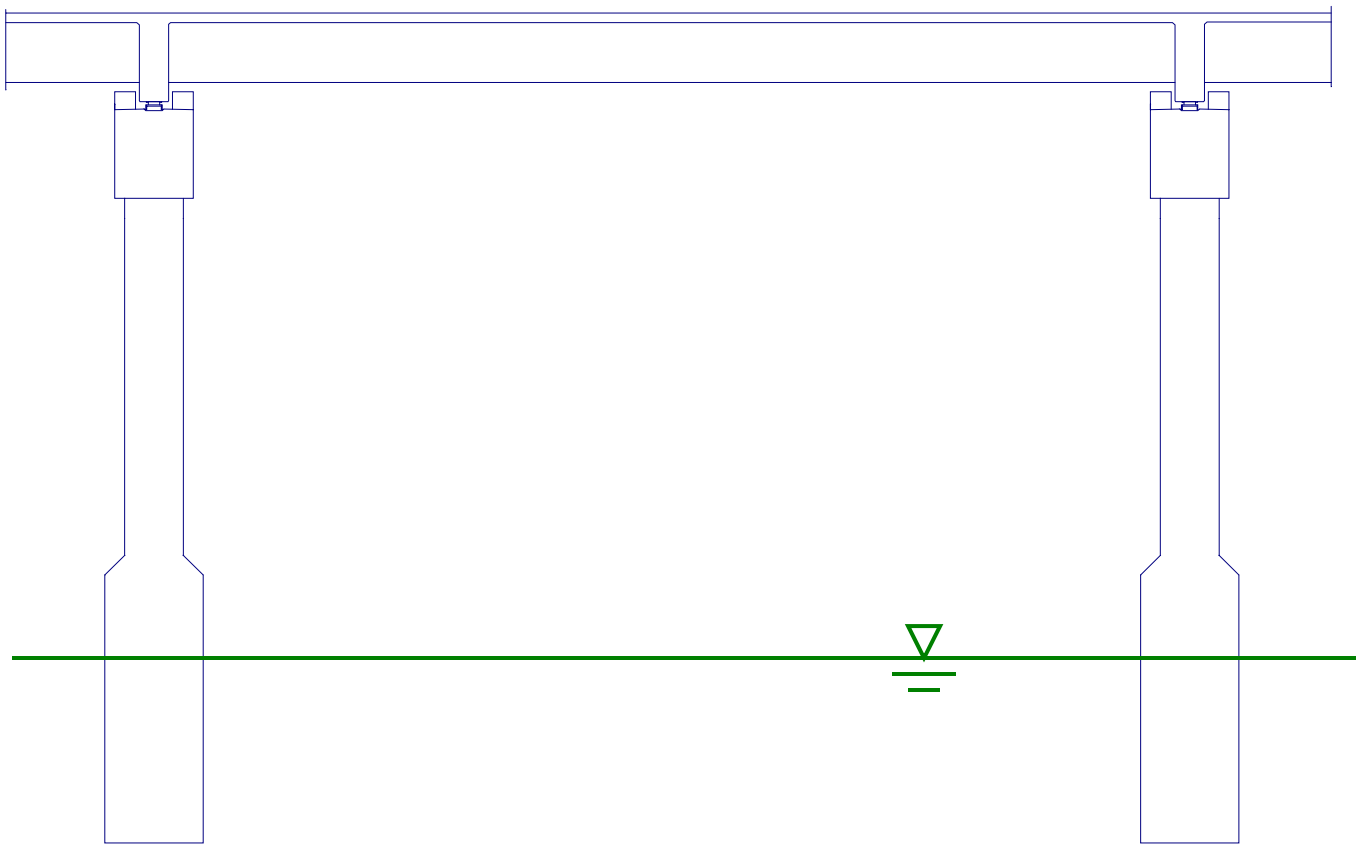
Hinge Diaphragm



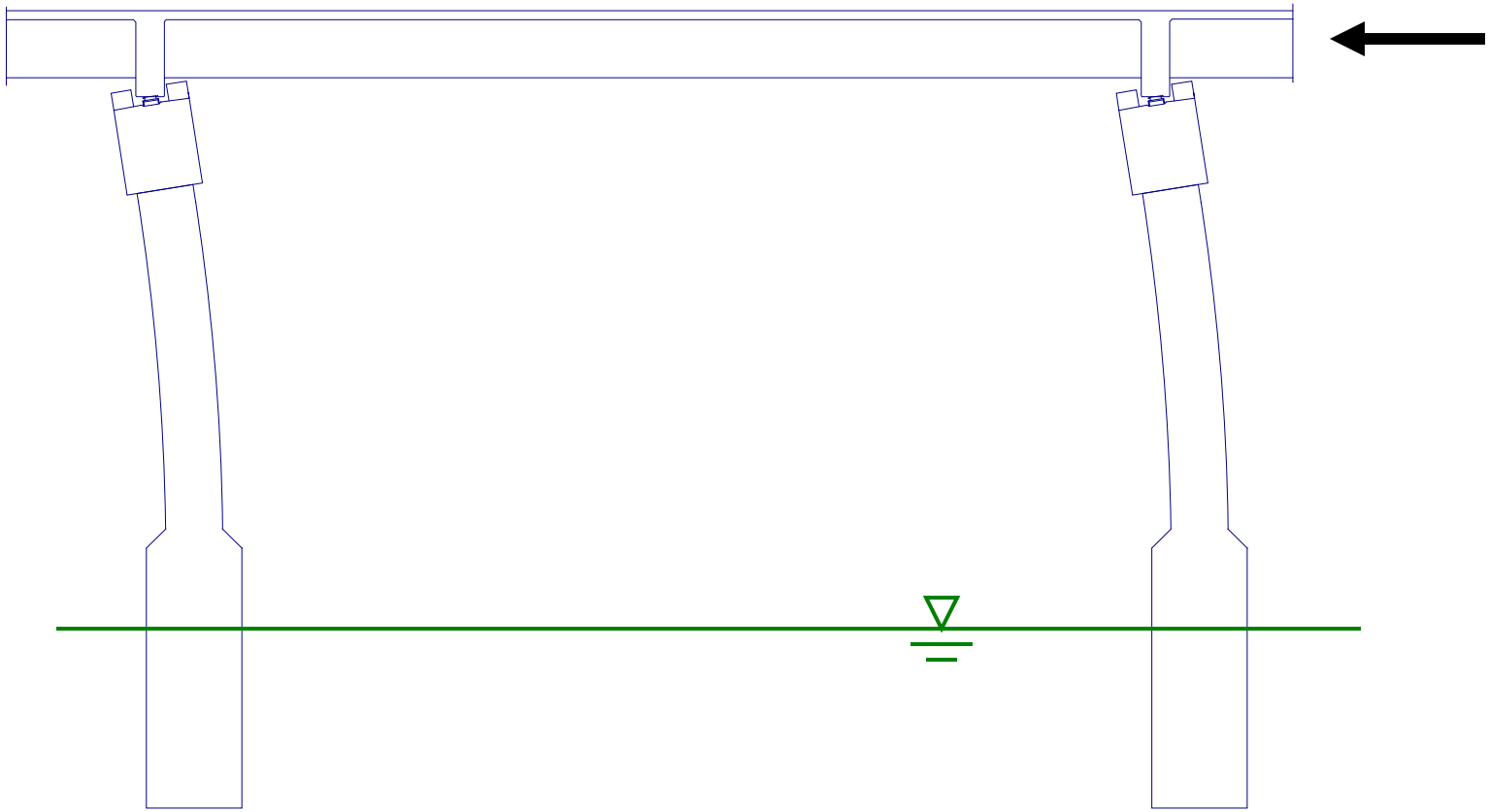
Hinge Diaphragm



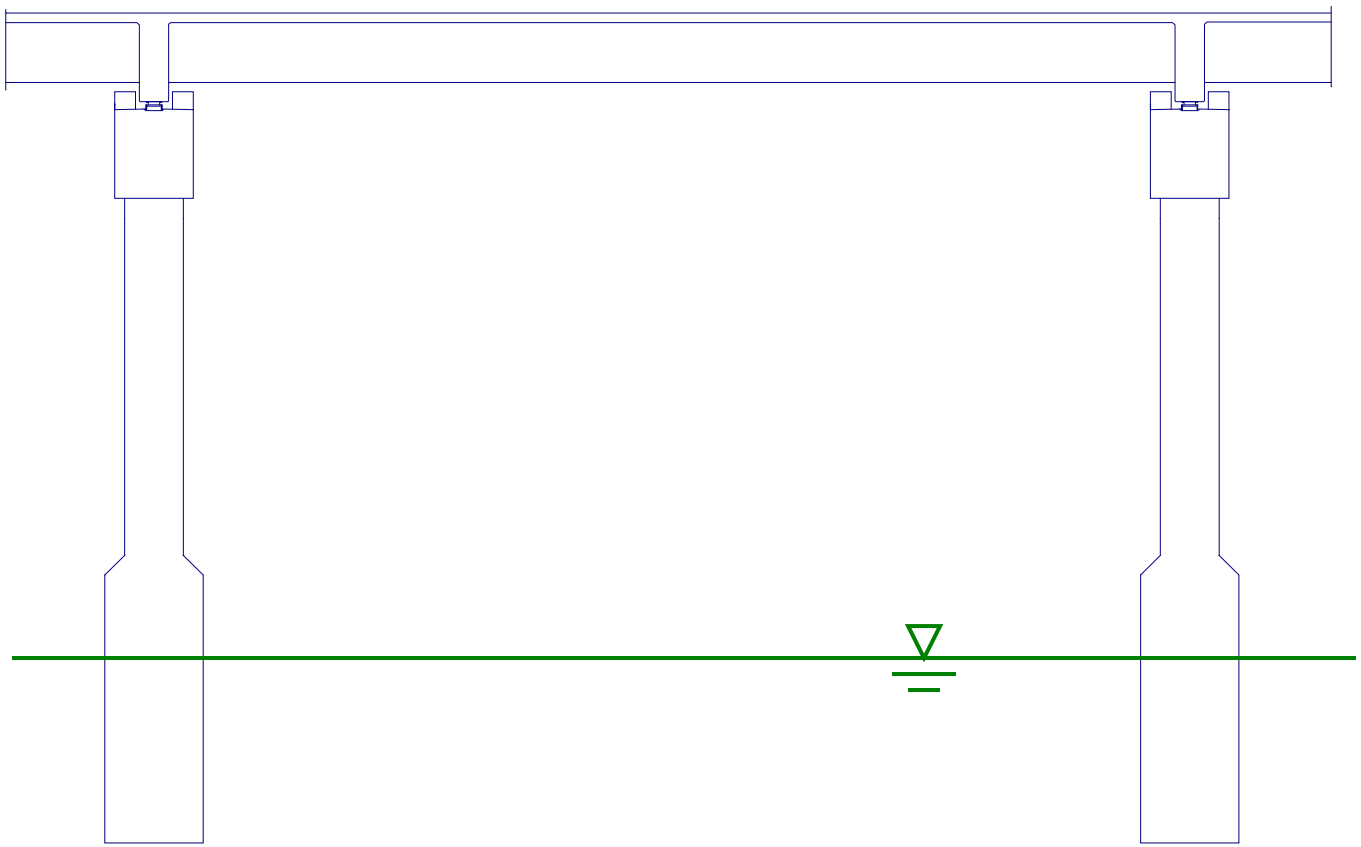
Hinge Diaphragm



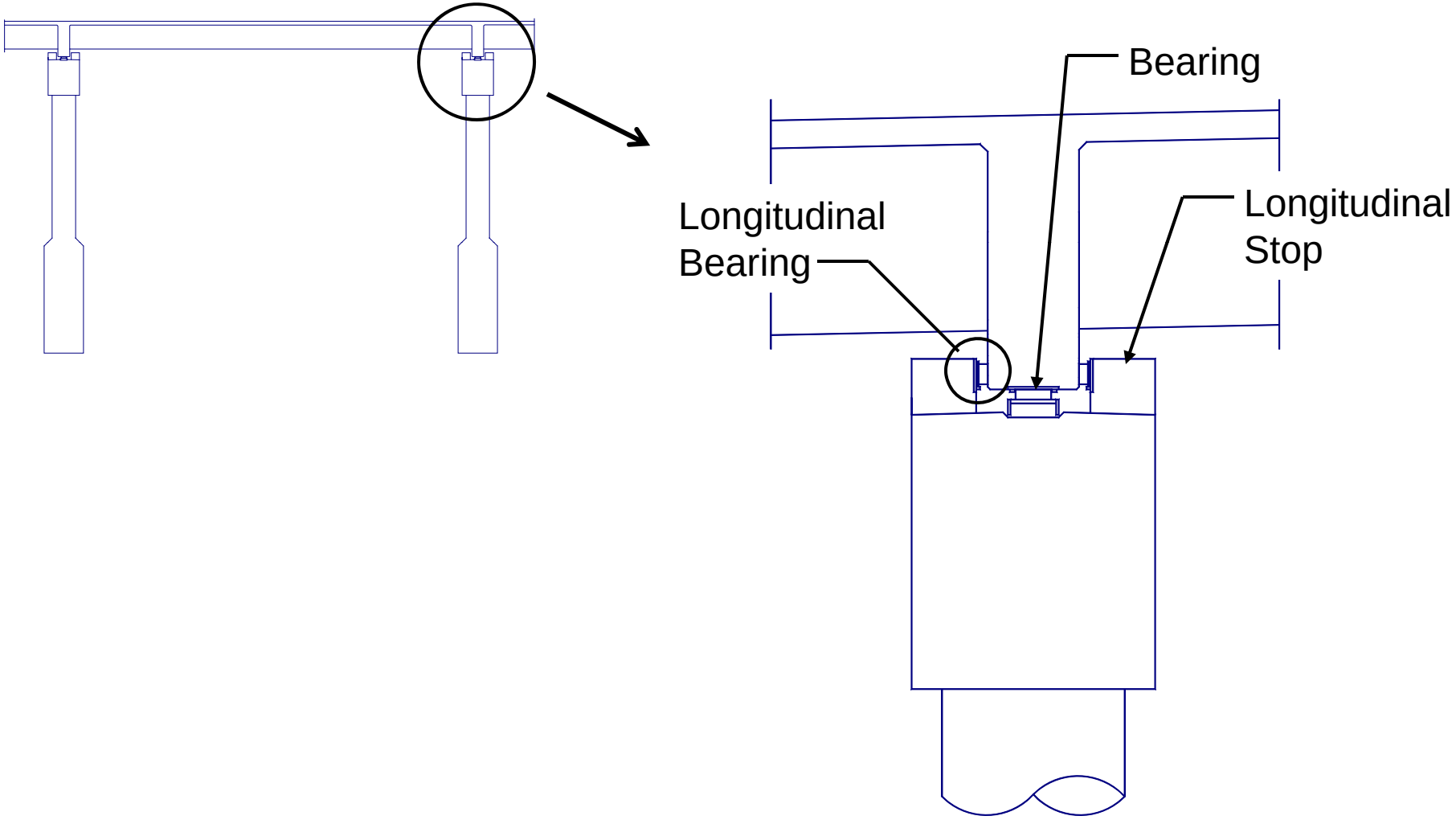
Hinge Diaphragm



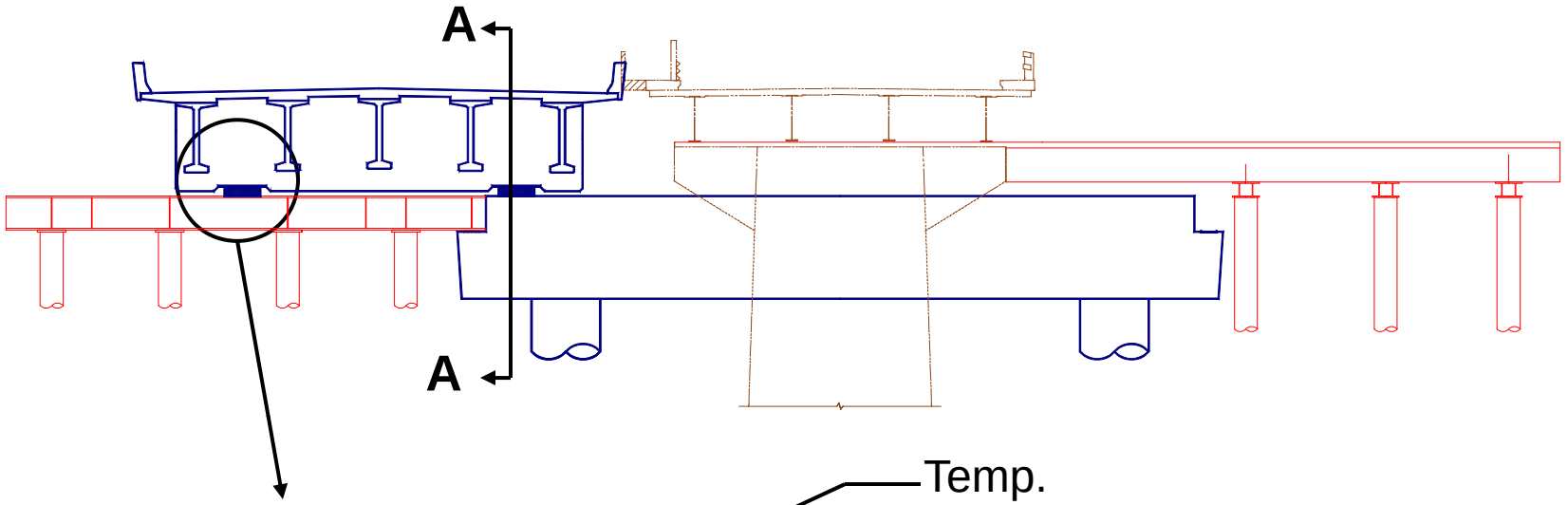
Hinge Diaphragm

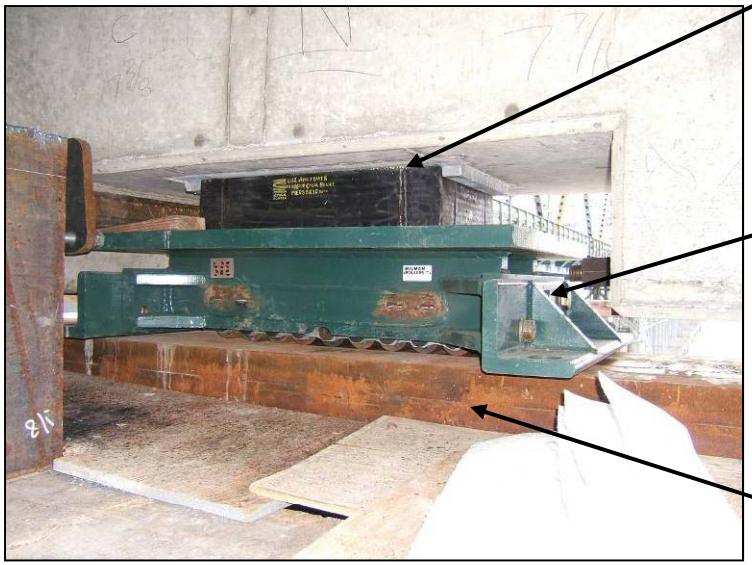


Hinge Diaphragm



Rolling Assembly



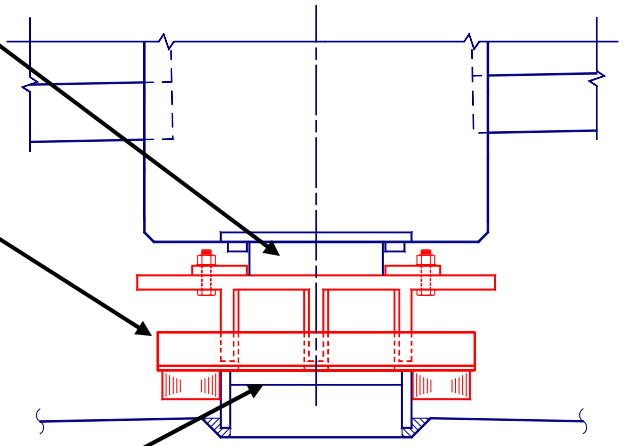


Hilman Roller

Temp.
Elast.
Brg.

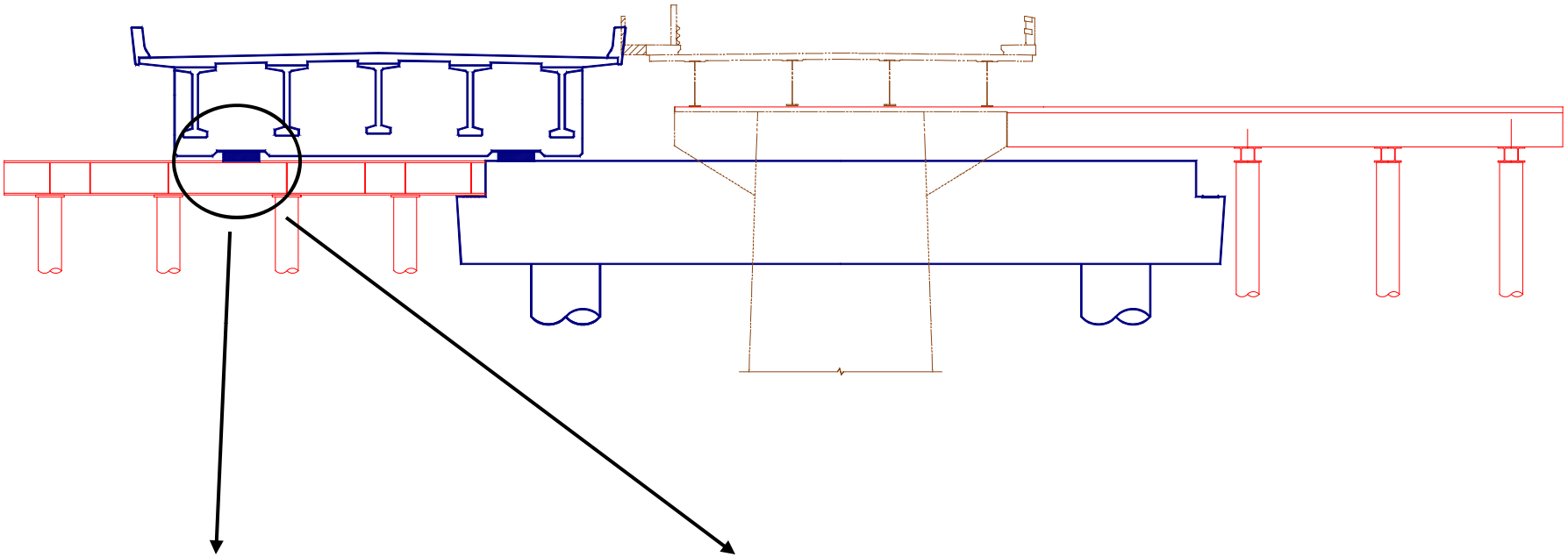
Hilman
Roller

Rolling
Plate



Section A-A

Hilman Rollers



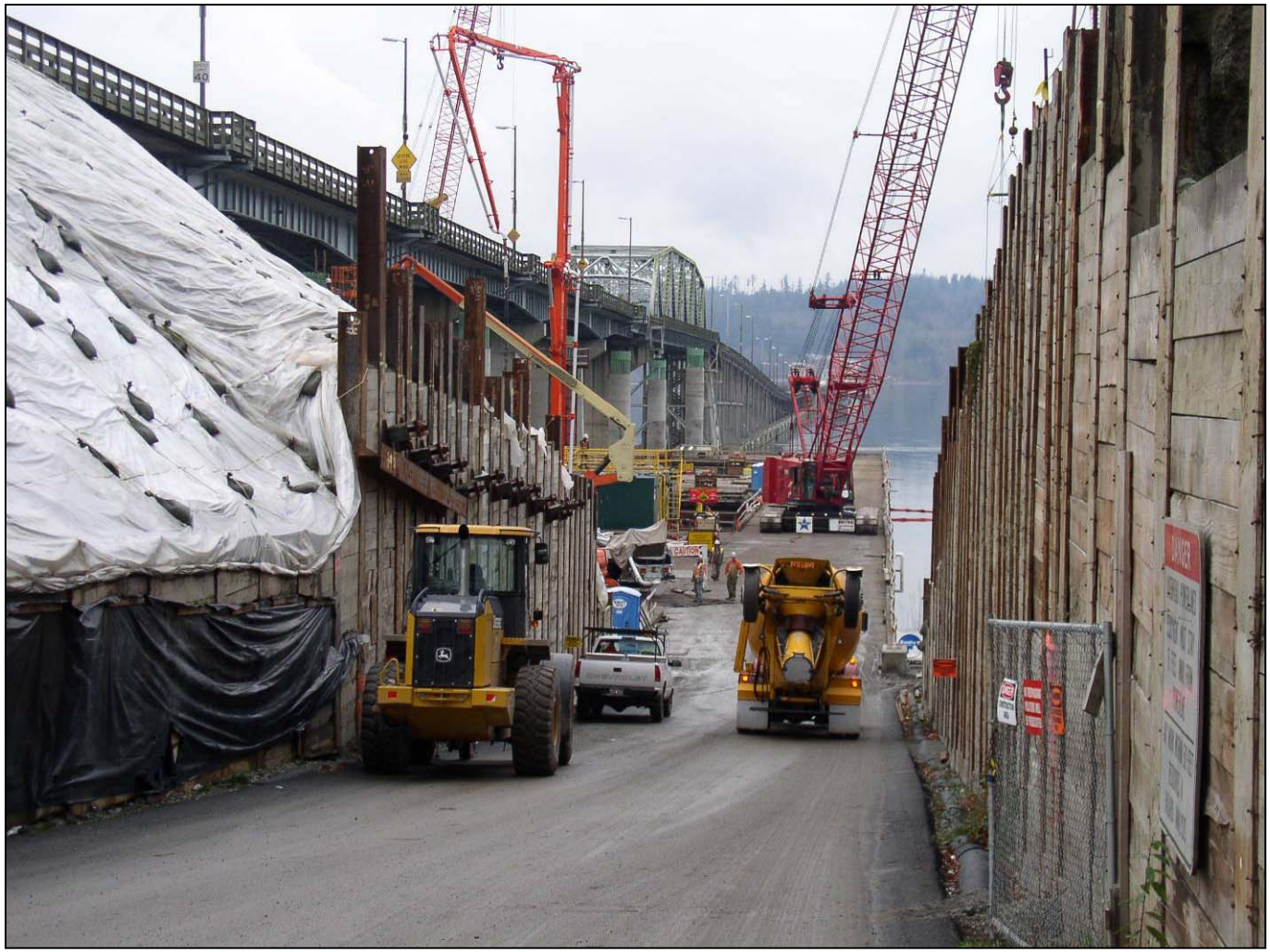
West Approach

- 1 span
- 1000 kip DL/Pier
- 2000 kips Total
- 2 Hilman rollers/span (300 ton capacity)

East Approach

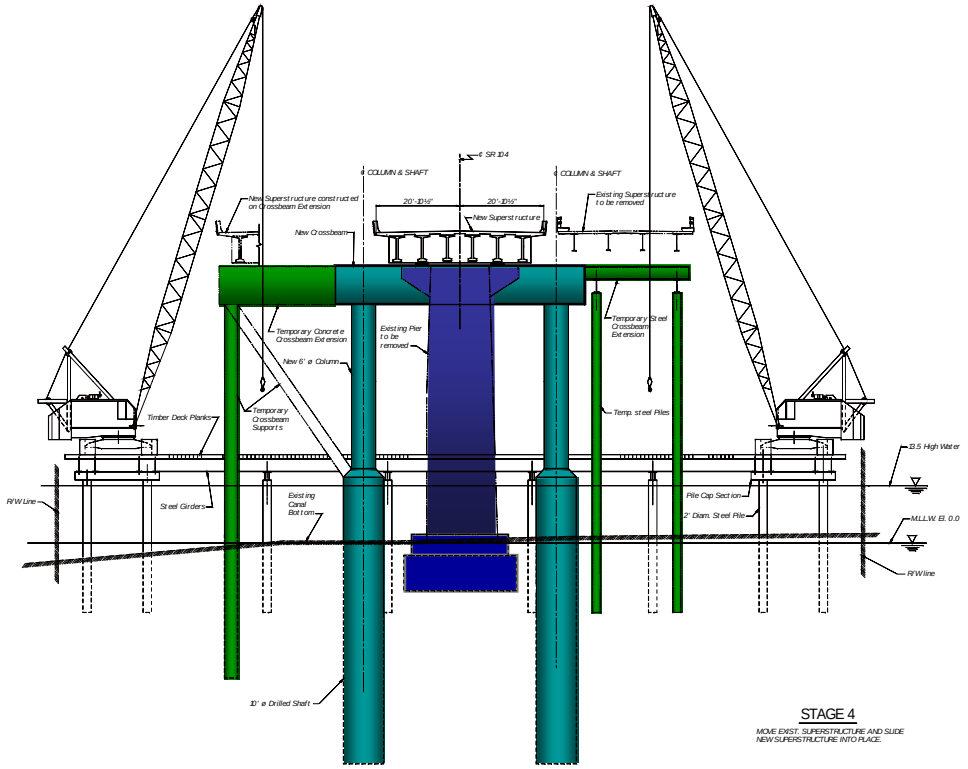
- 5 spans
- 800 to 1500 kips DL/Pier
- 7600 kips Total
- 2 Hilman rollers/span (300 or 500 ton capacity)

Construction



Work Trestle

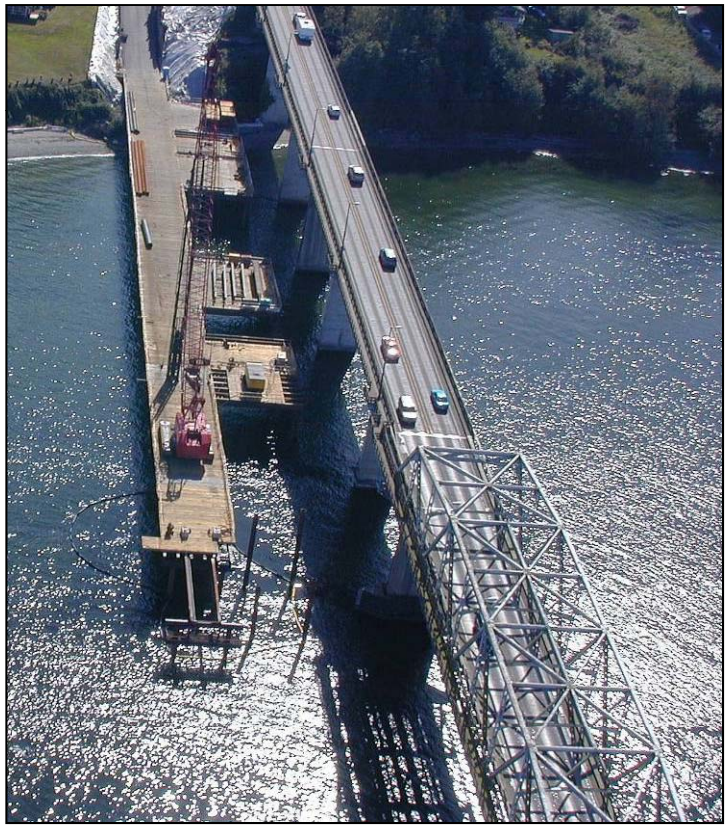
- Trestle and Falsework scheme included in Contract
- Contractor required to submit for review and approval
- Falsework system designed for ½ seismic acceleration (0.15g)



Work Trestle

- 58,000 ft^2
- 260 – 2’ Diameter Piles
- 4 months to construct

East Approach



Substructure

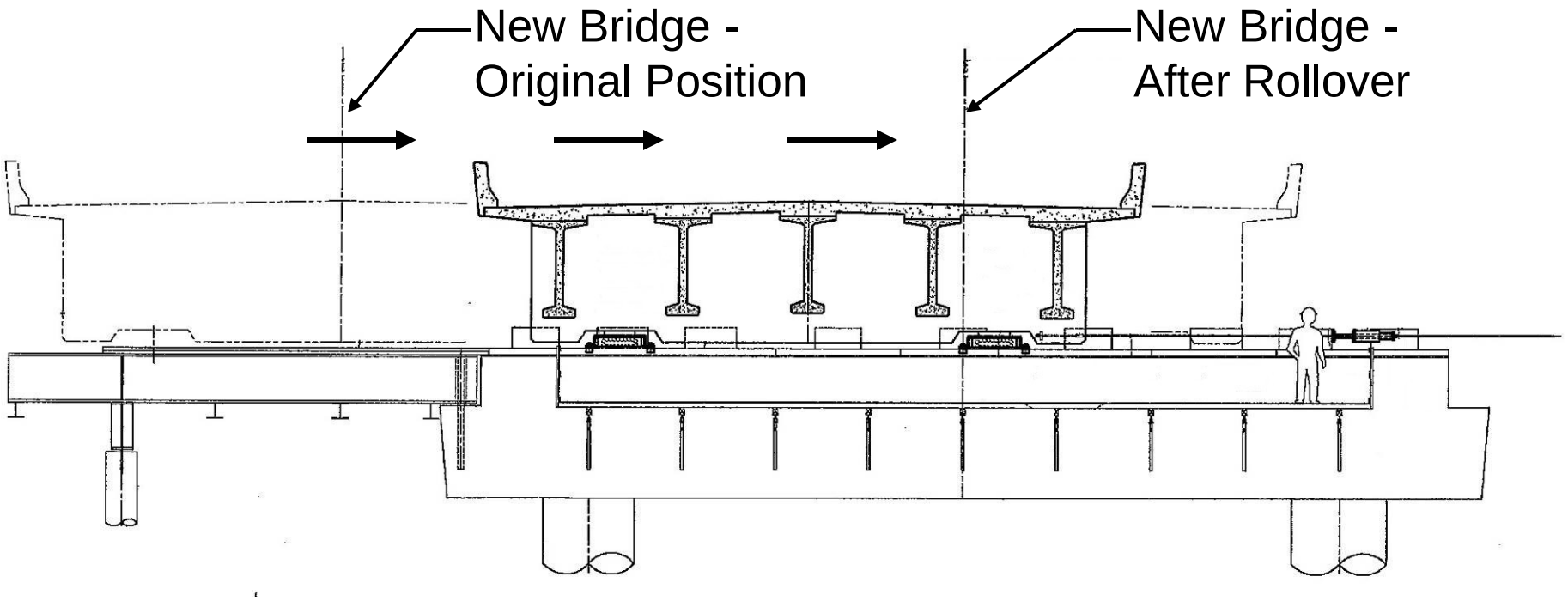
- 12 – 10’ Diameter Shafts
- 5 ½ Months Construction
- Epoxy Coated Rebar – Entire Structure

} East Approach

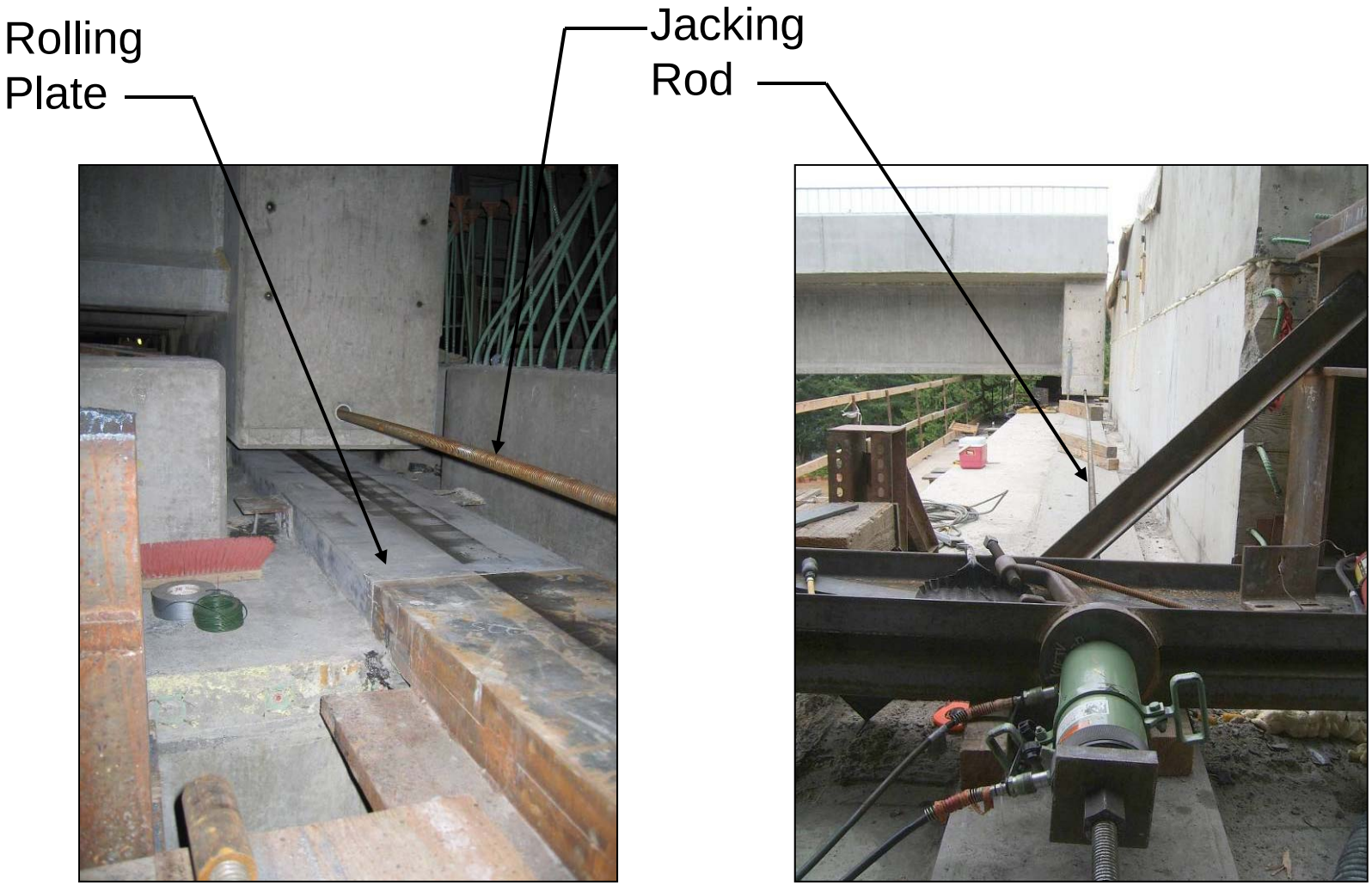
Superstructure

Hydraulic Jacking – Horizontal

- West Approach – 2 synchronized jacks
- East Approach – 6 synchronized jacks
- Max horizontal force/jack – 30 to 80 kips
- Max ¼" differential horizontal movement between adjacent piers during rolling

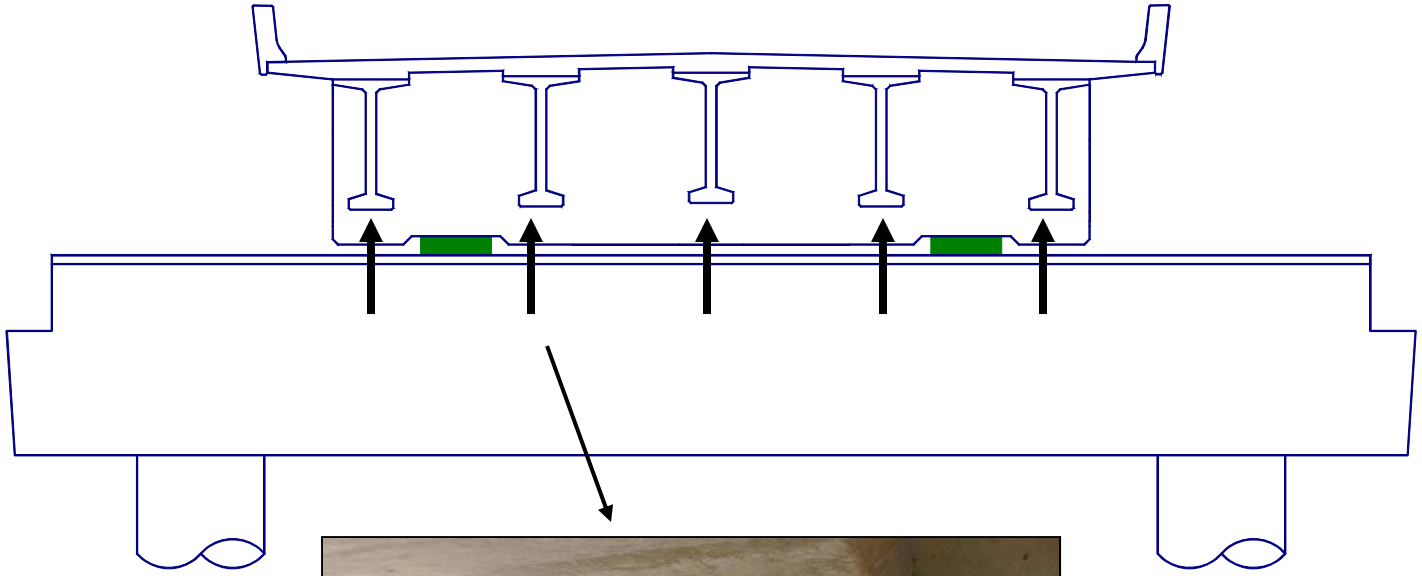


Hydraulic Jacking – Horizontal

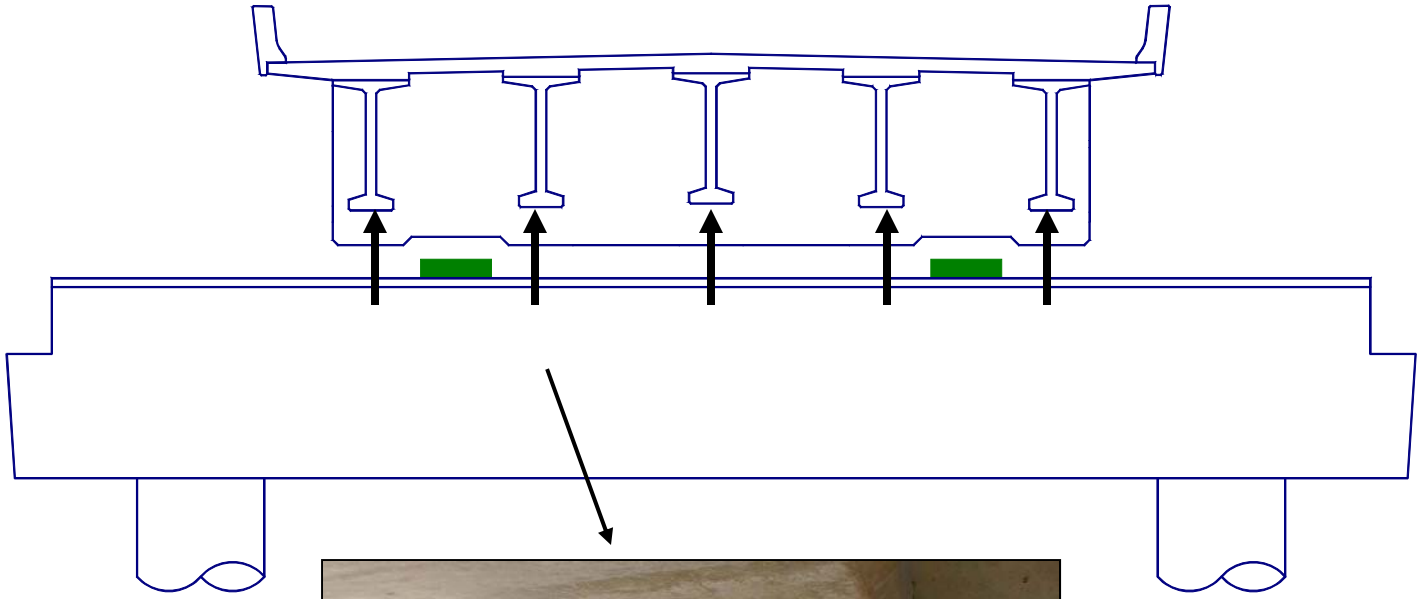


The Rollover

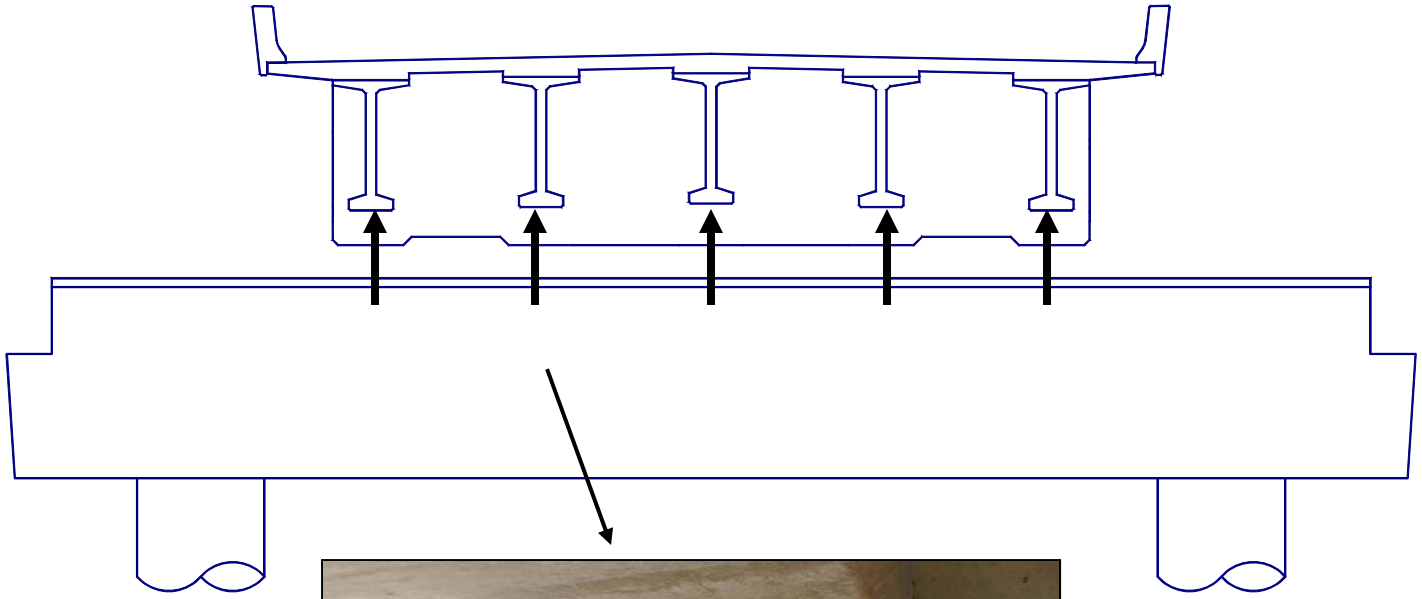
Hydraulic Jacking – Vertical



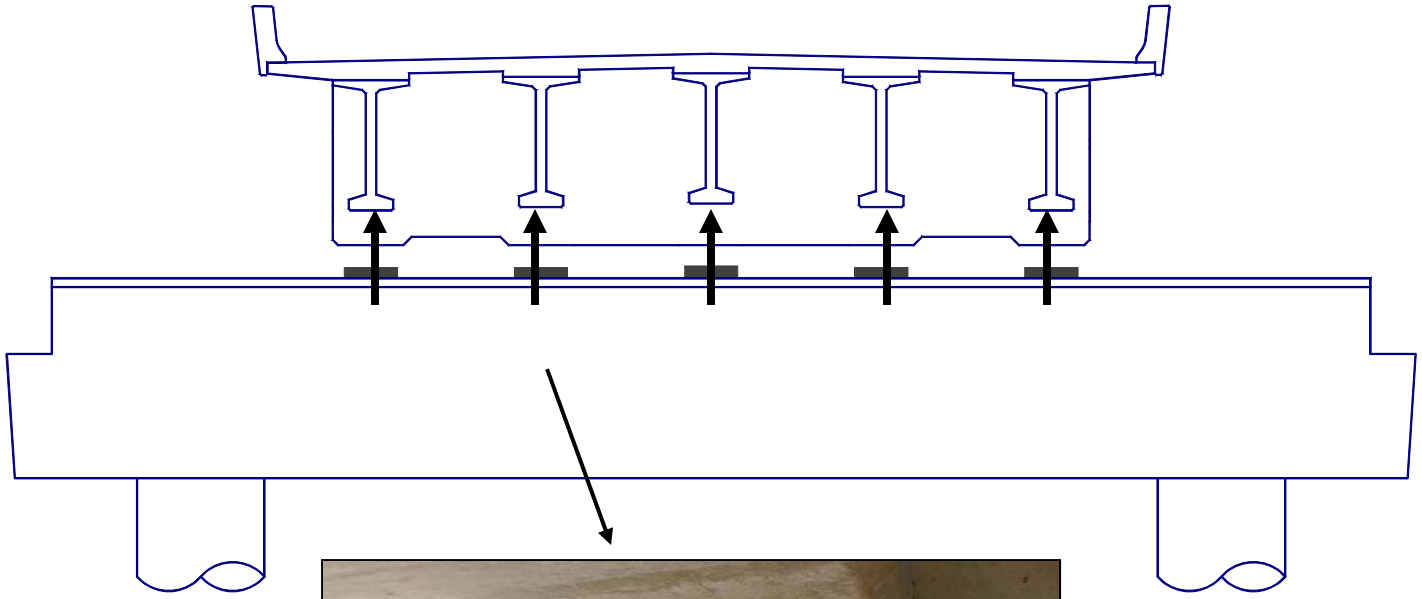
Hydraulic Jacking – Vertical



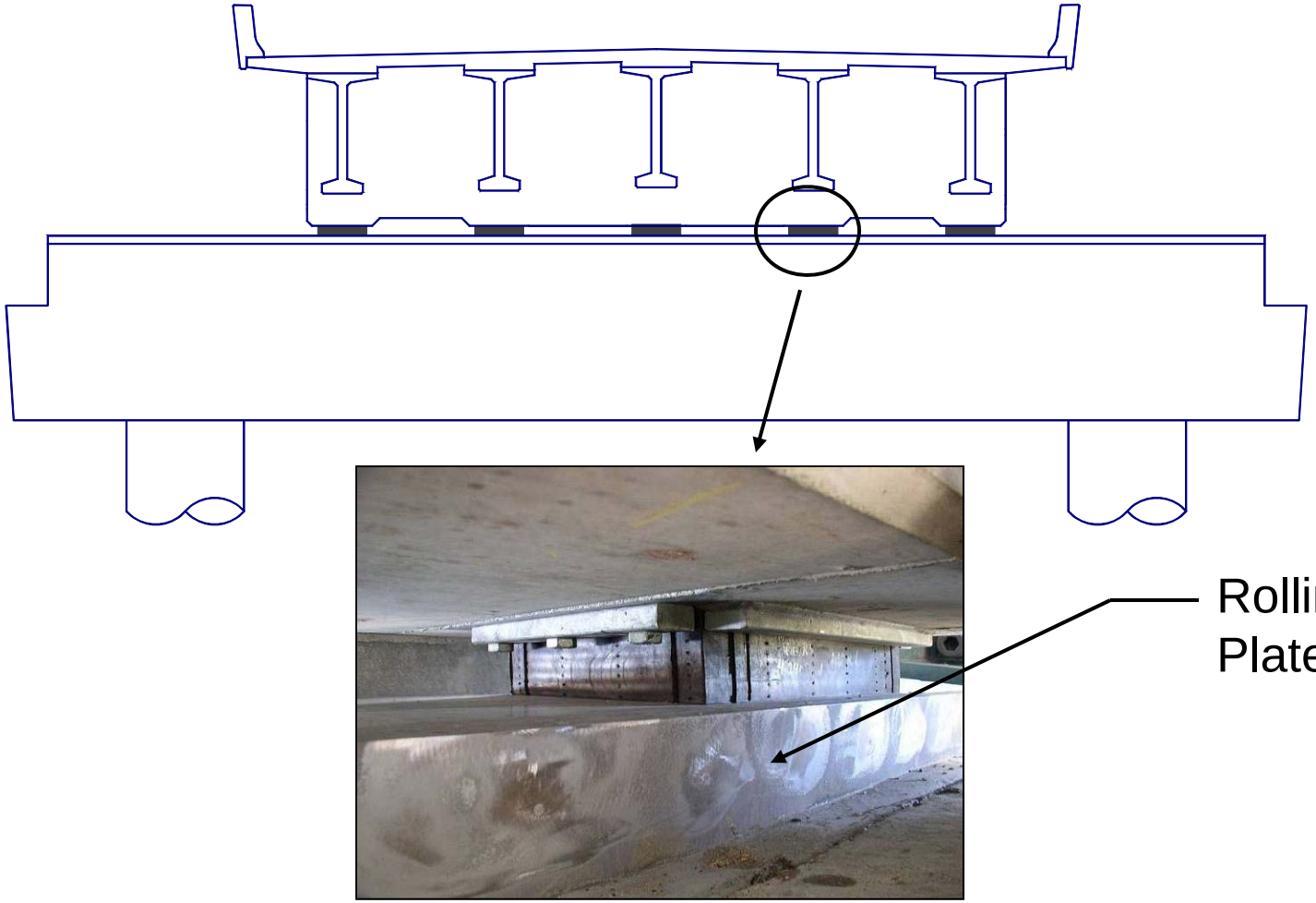
Hydraulic Jacking – Vertical



Hydraulic Jacking – Vertical

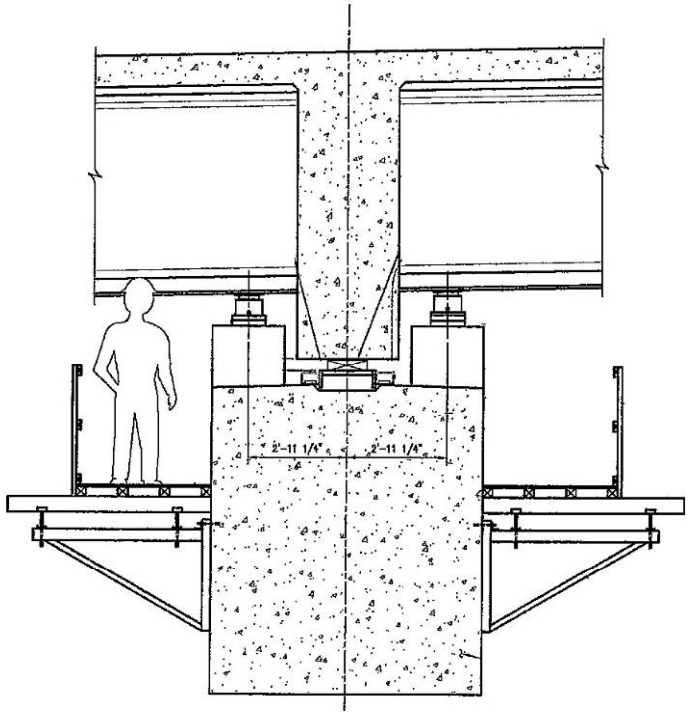


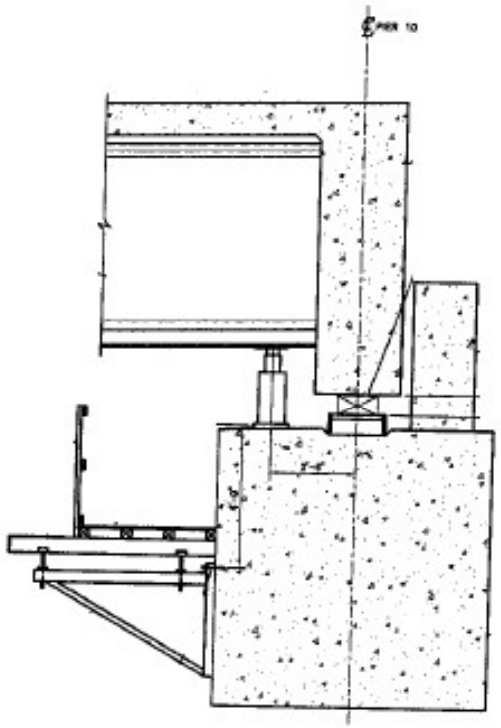
Hydraulic Jacking – Vertical



Hydraulic Jacking – Vertical

- Jacking performed pier by pier
- 10 synchronized jacks interior piers, 5 at end piers
- Max relative differential movement between jacks = ¼”
- Max relative differential movement between piers = 2”
- Pressure system used for vertical jacking





East Approach Aerial Photos

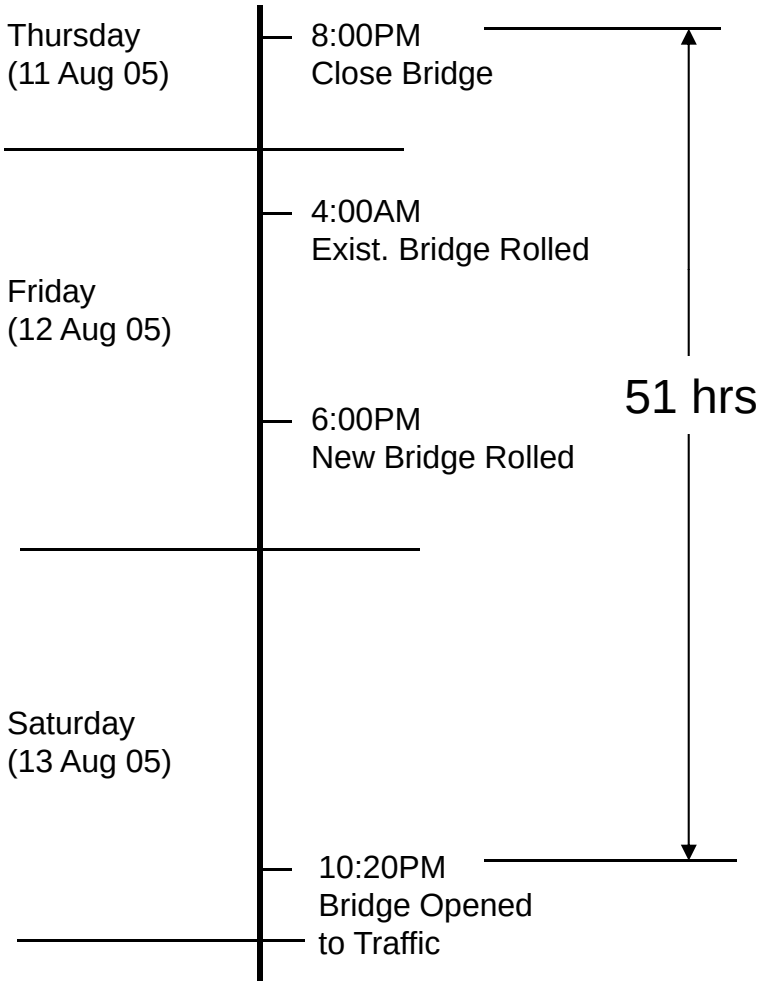
Before

During

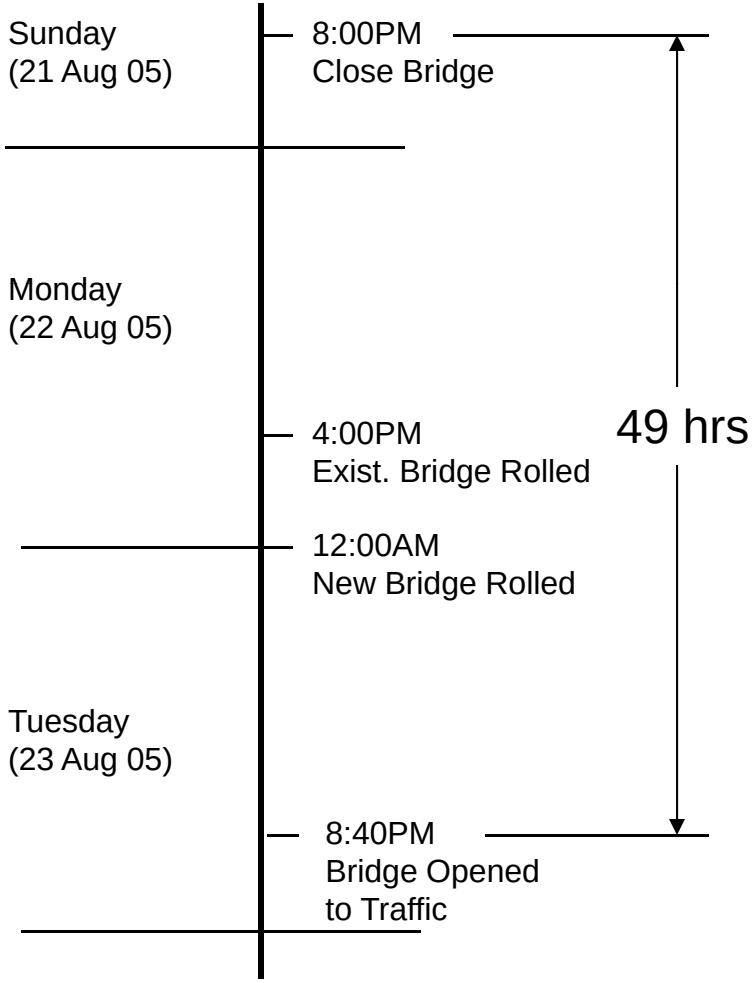
After

Approach Closure Schedule

West Approach



East Approach

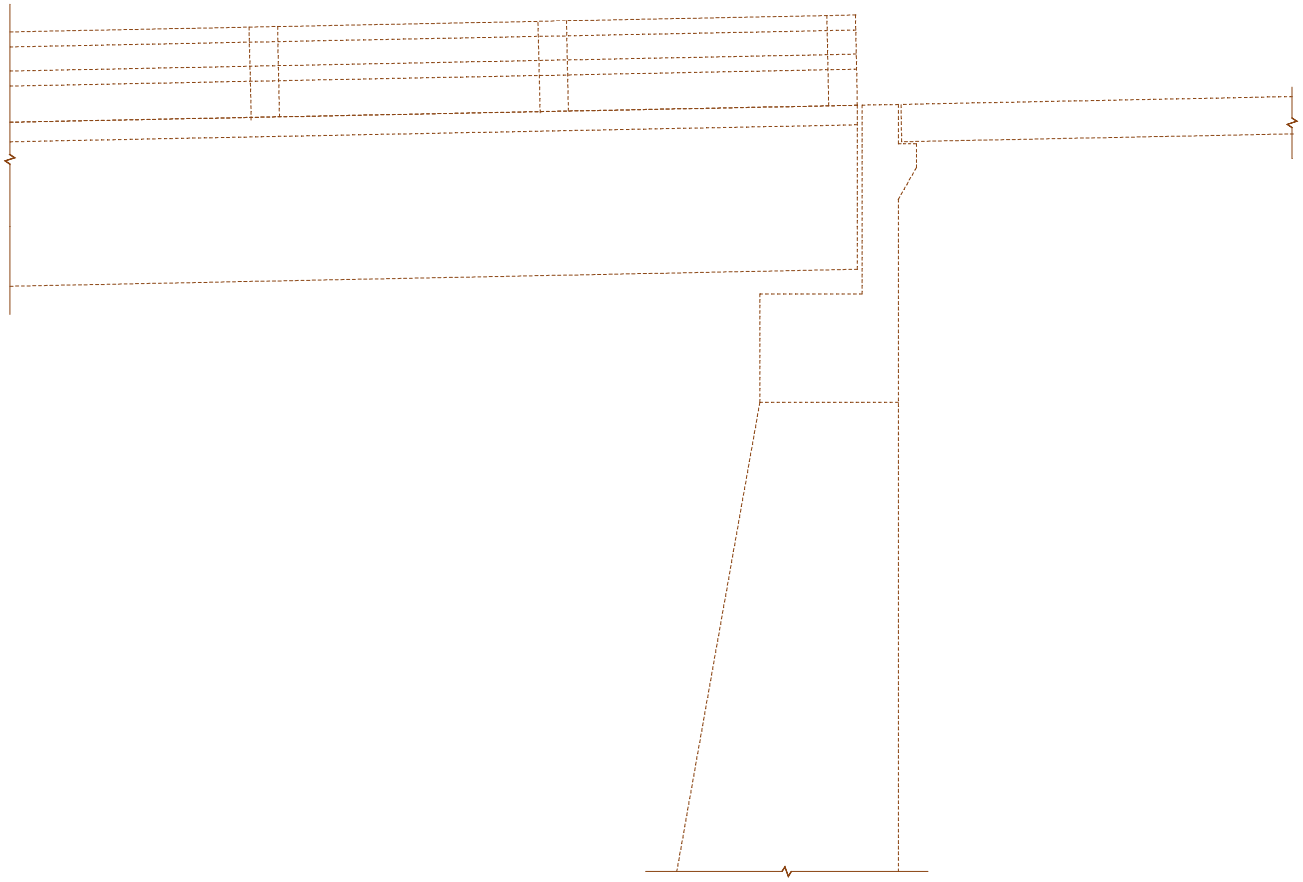


Closure Challenges

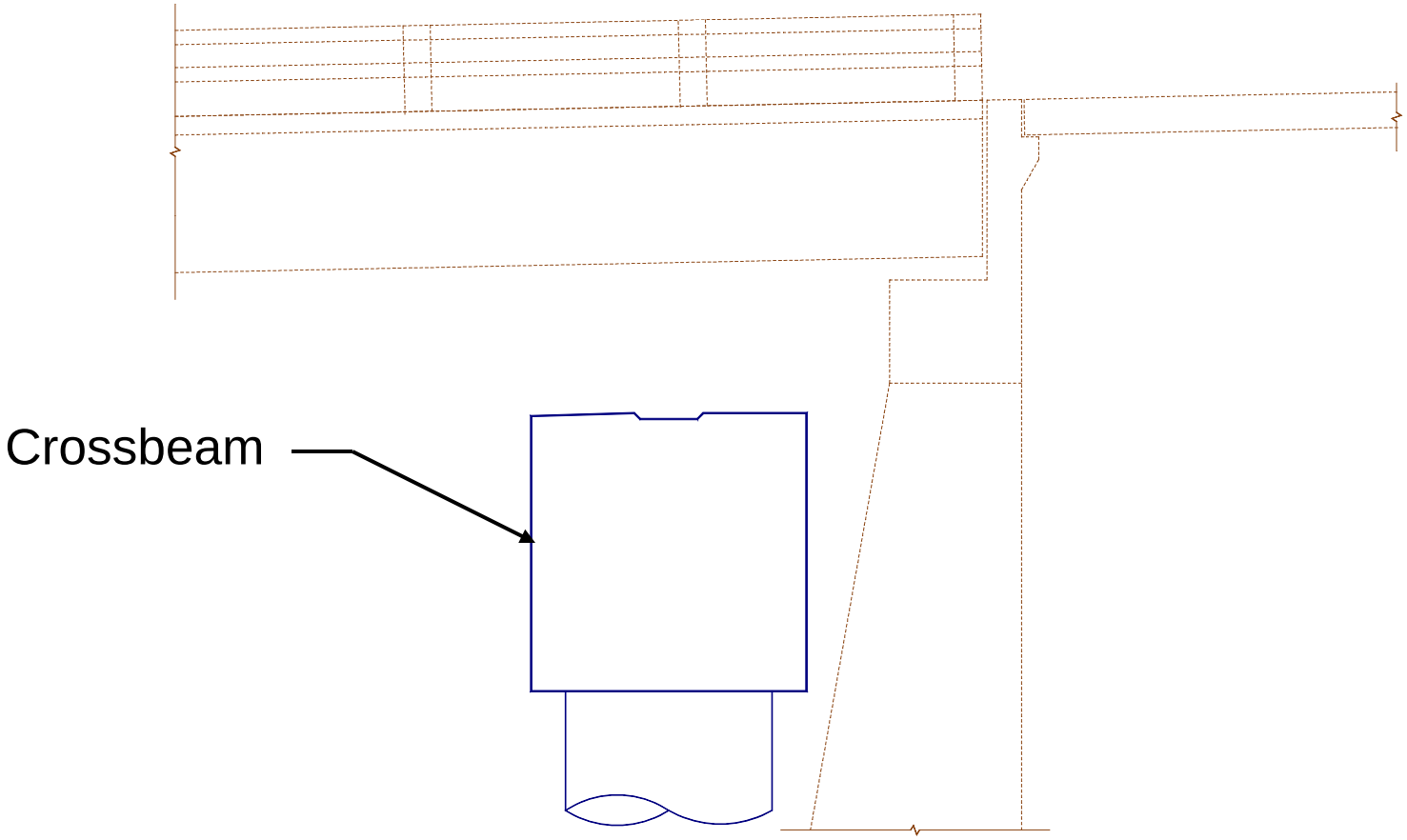
Abutment and Approach Slabs

- Precast Abutment Endwall
- Precast Approach Slabs

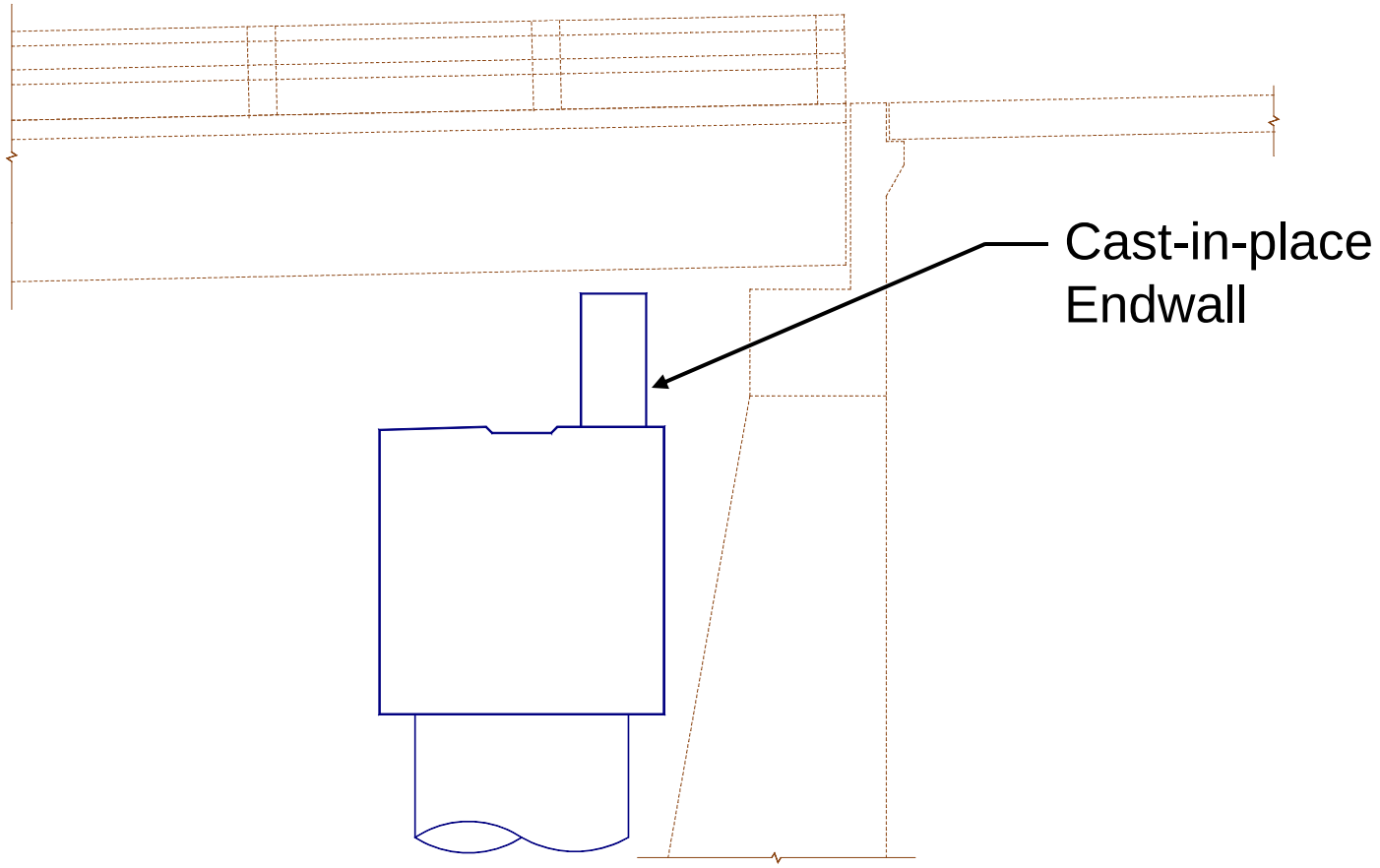
Abutments



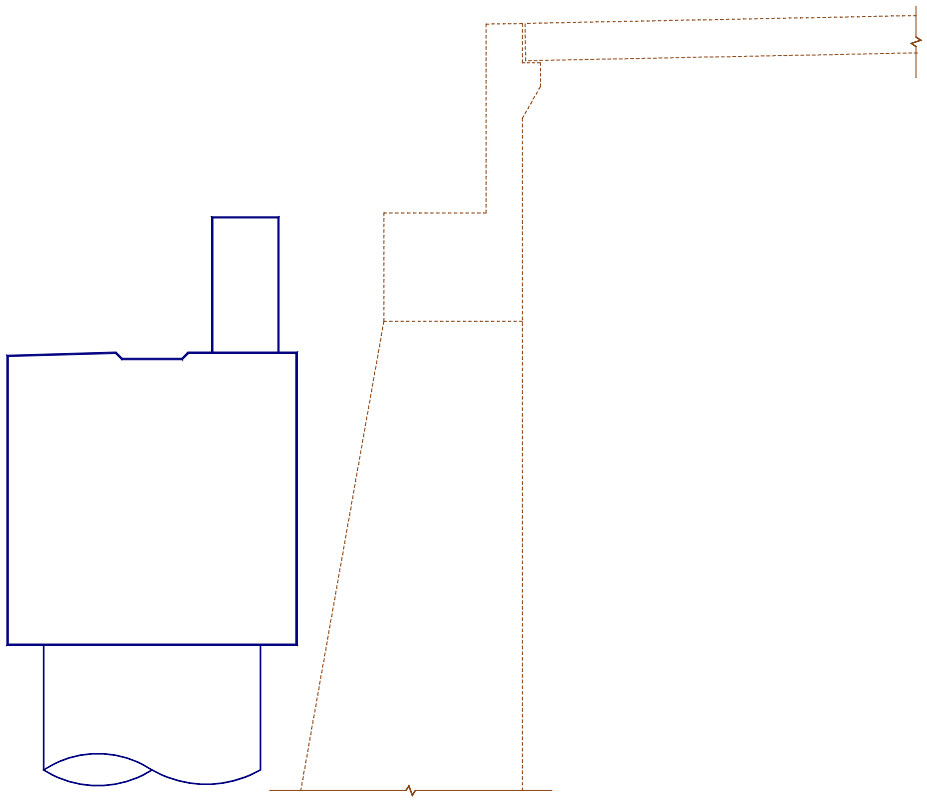
Abutments



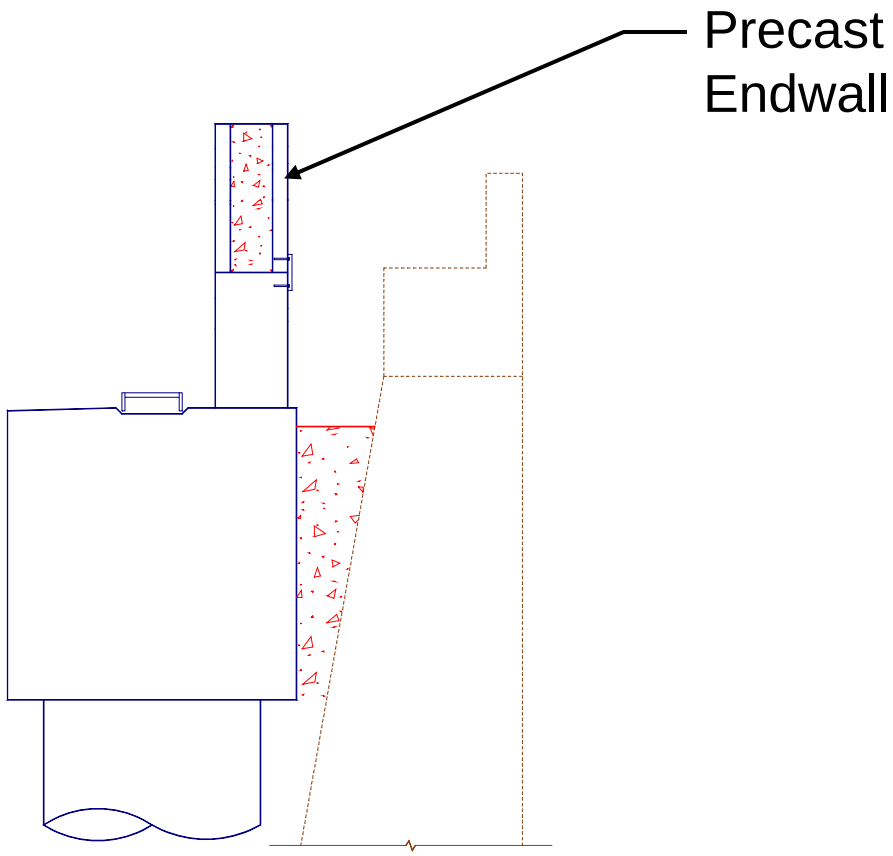
Abutments



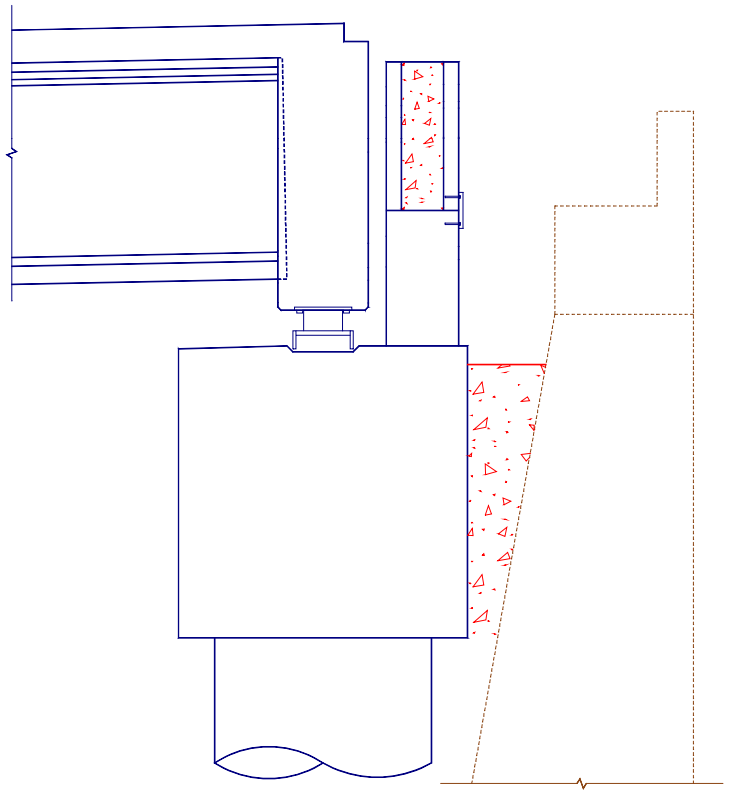
Abutments



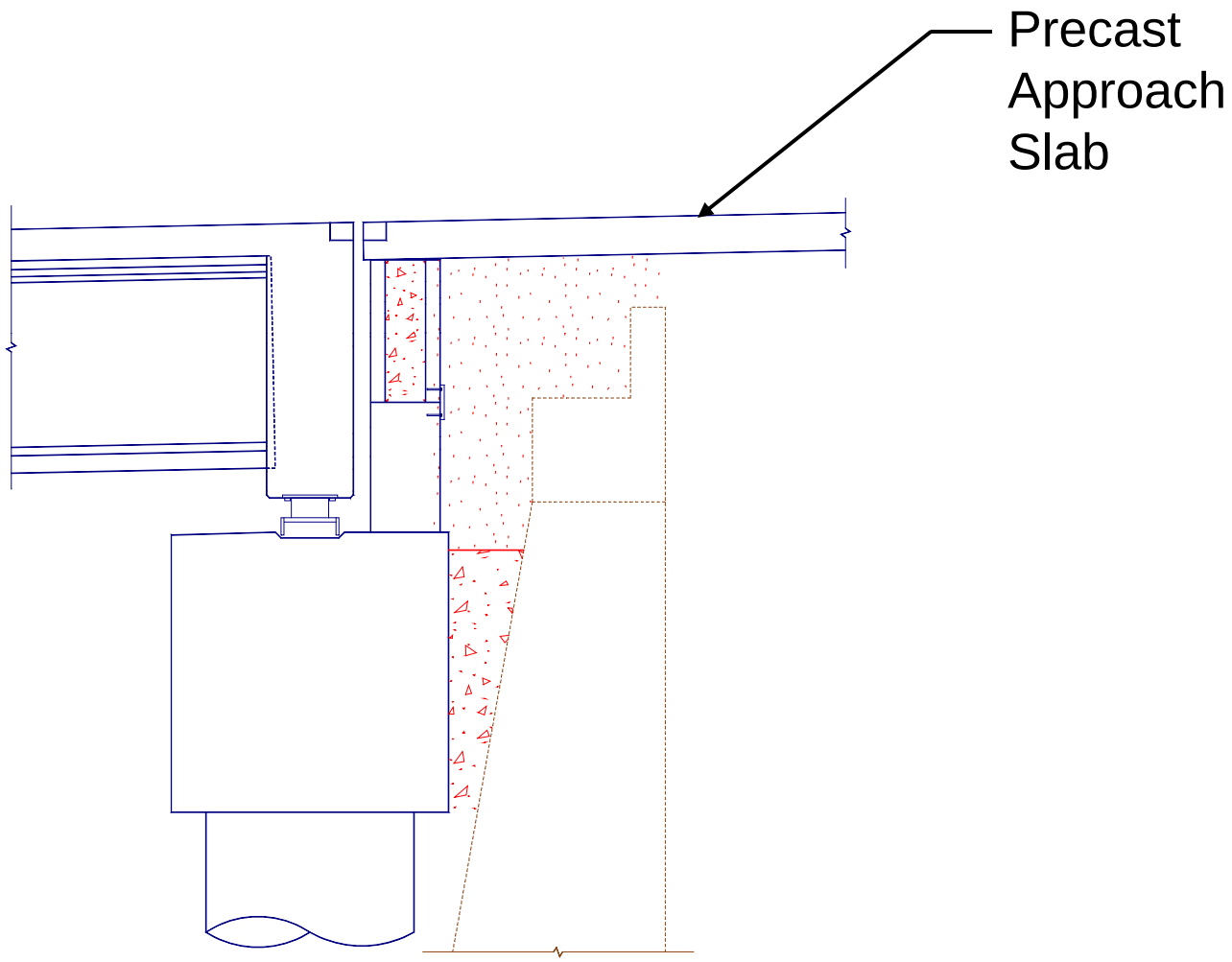
Abutments



Abutments



Abutments



Precast Abutment Endwall Construction

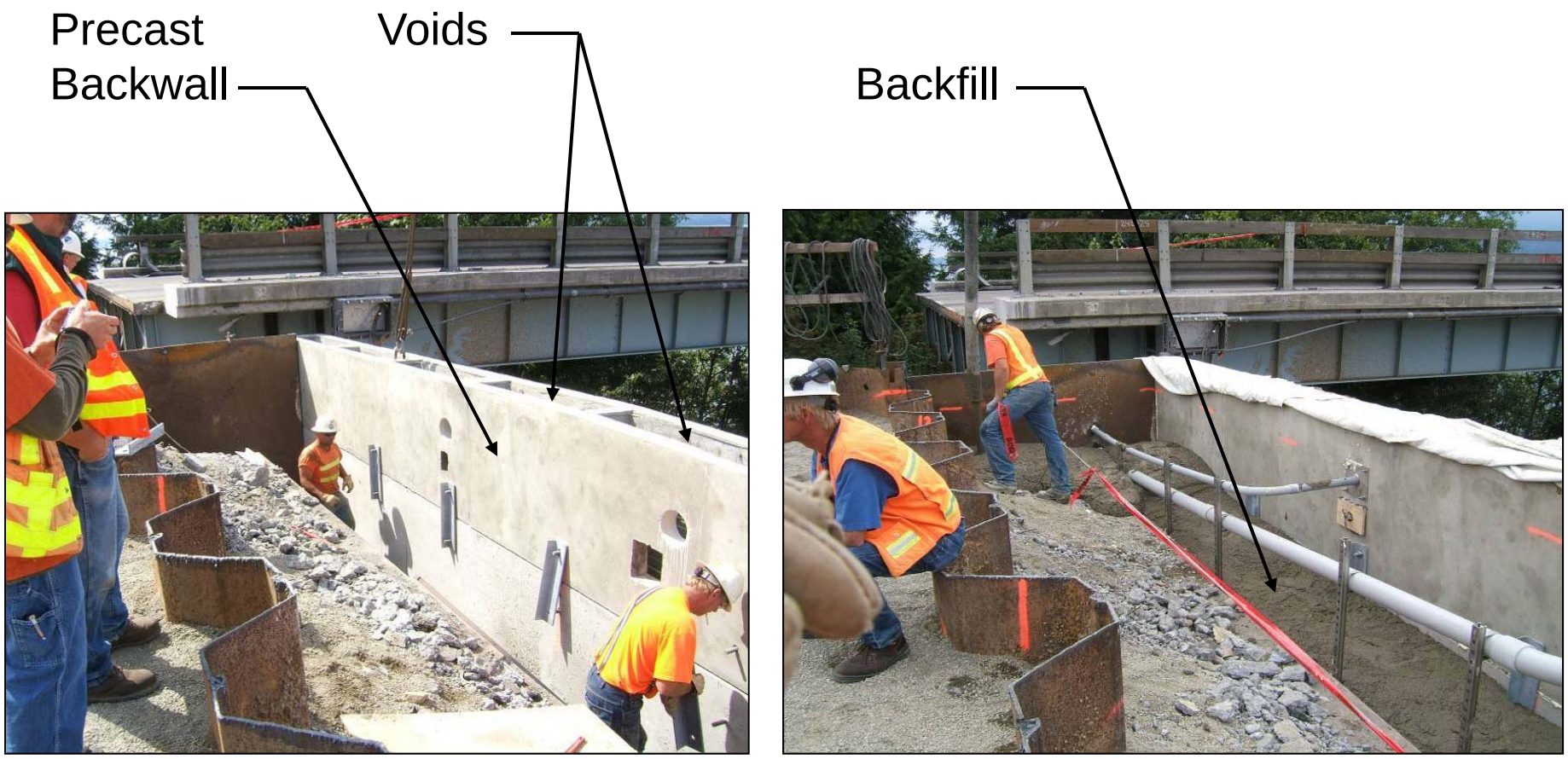
Precast Endwall

Cast-in-place Endwall

Cast-in-Place Endwall

Precast Endwall

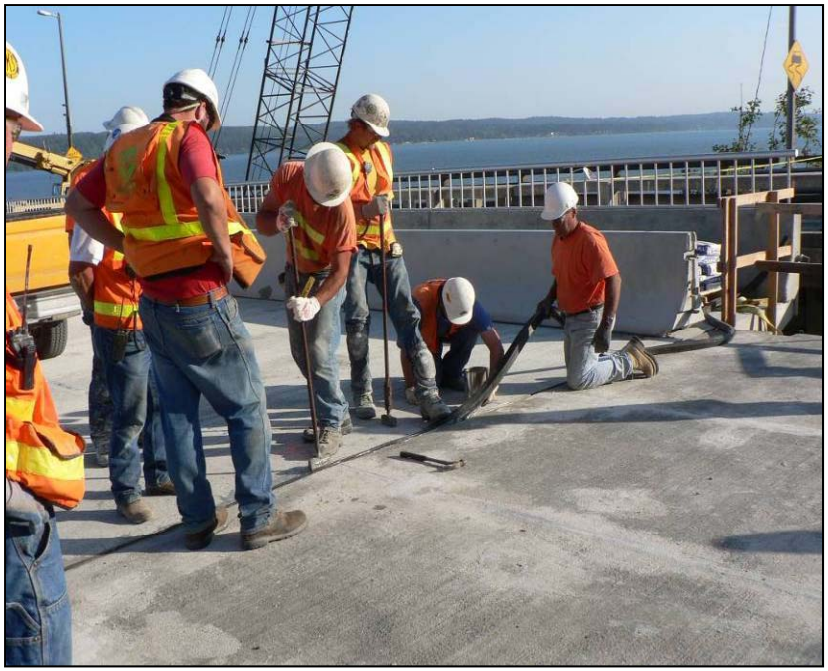
Precast Abutment Endwall Construction



Precast Approach Slab

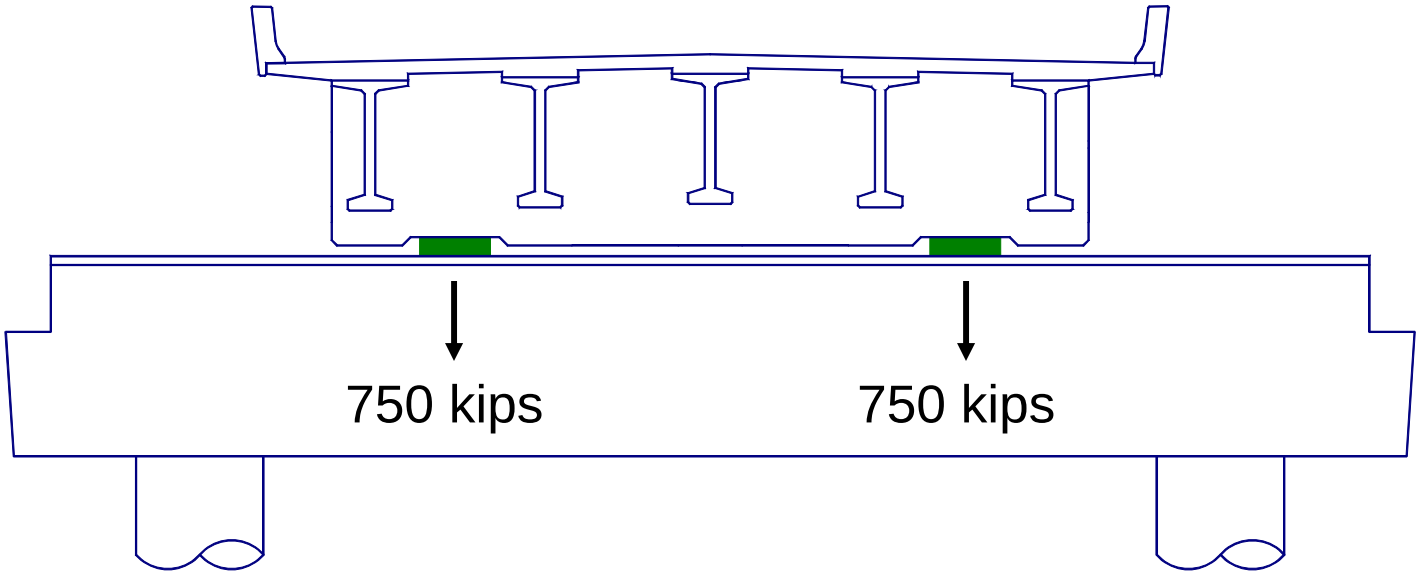
- 6 Sections
- 25’ x 8’ x 1’-1”

Expansion Joints



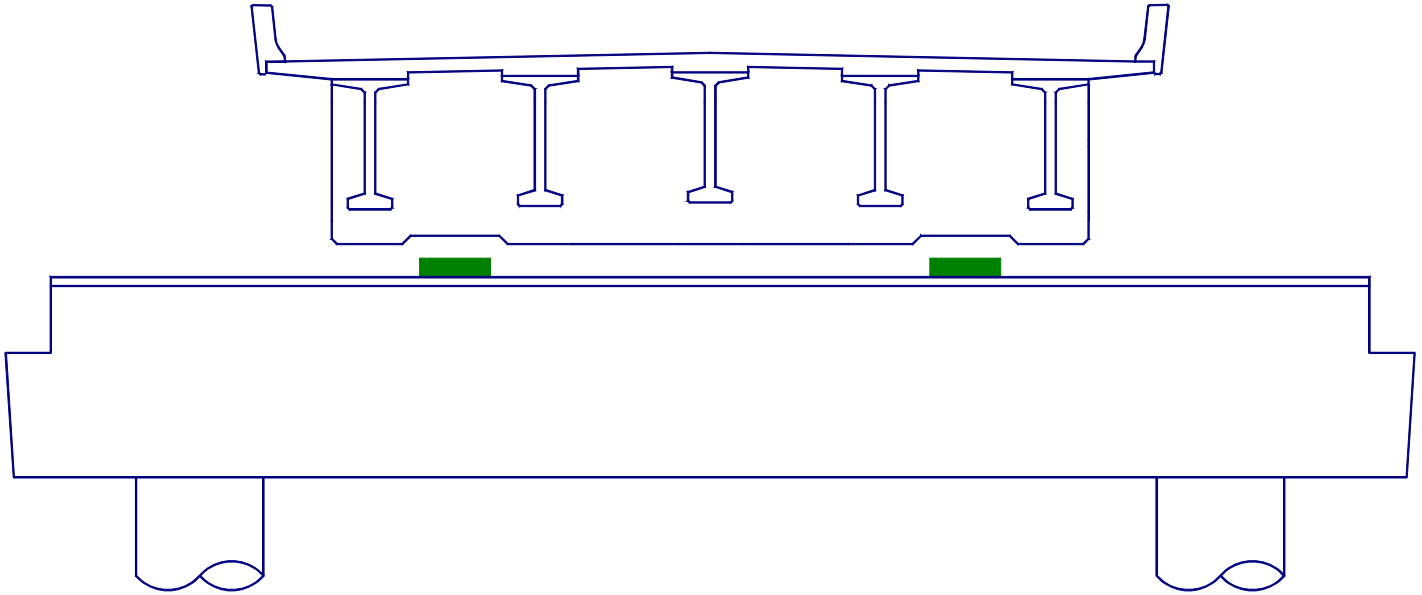
Lessons Learned

Unequal Bearing Loads



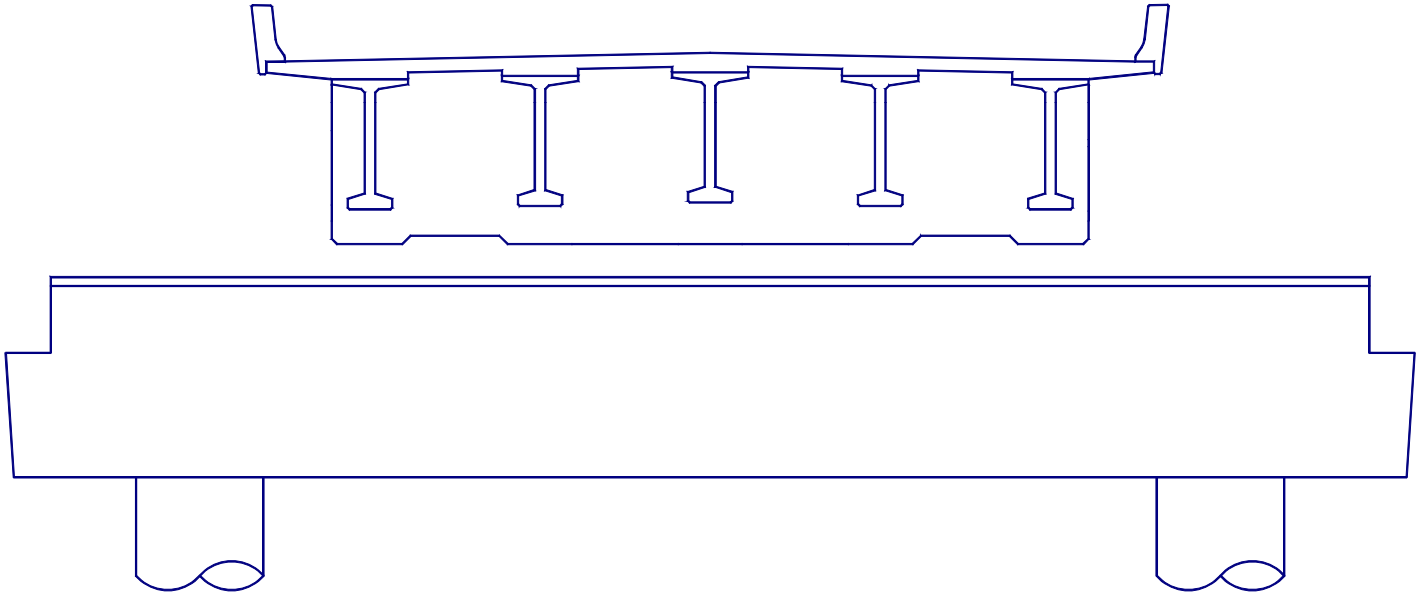
Lessons Learned

Unequal Bearing Loads



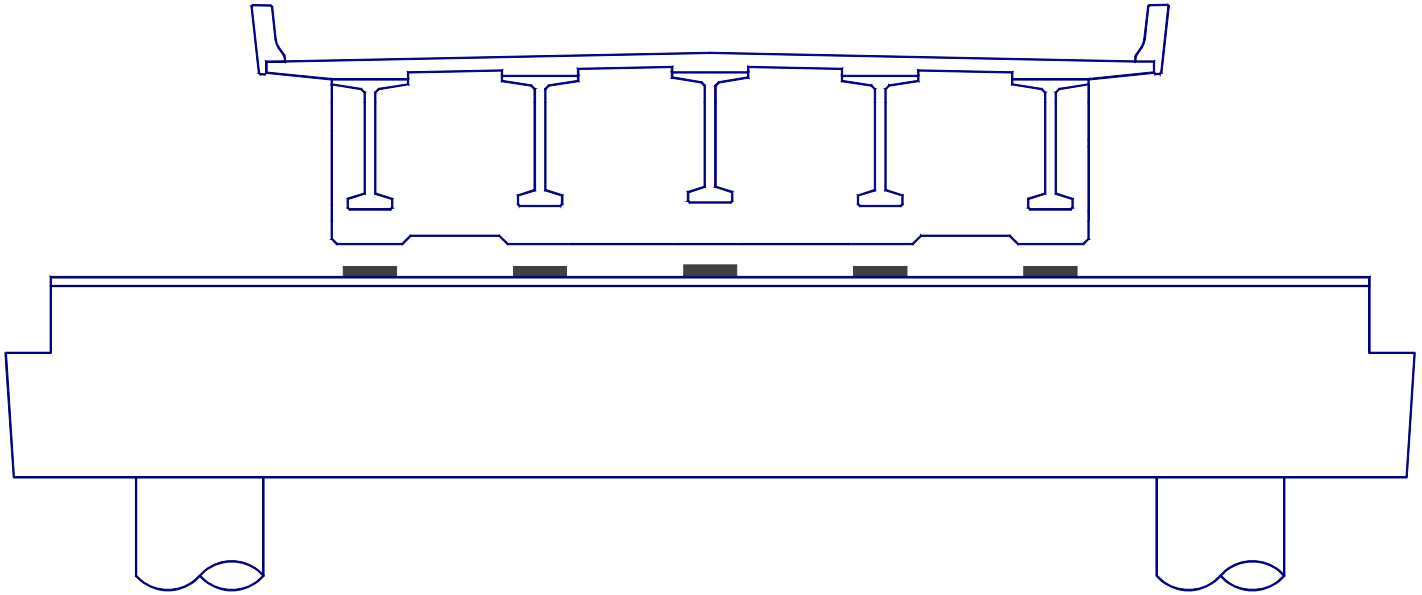
Lessons Learned

Unequal Bearing Loads



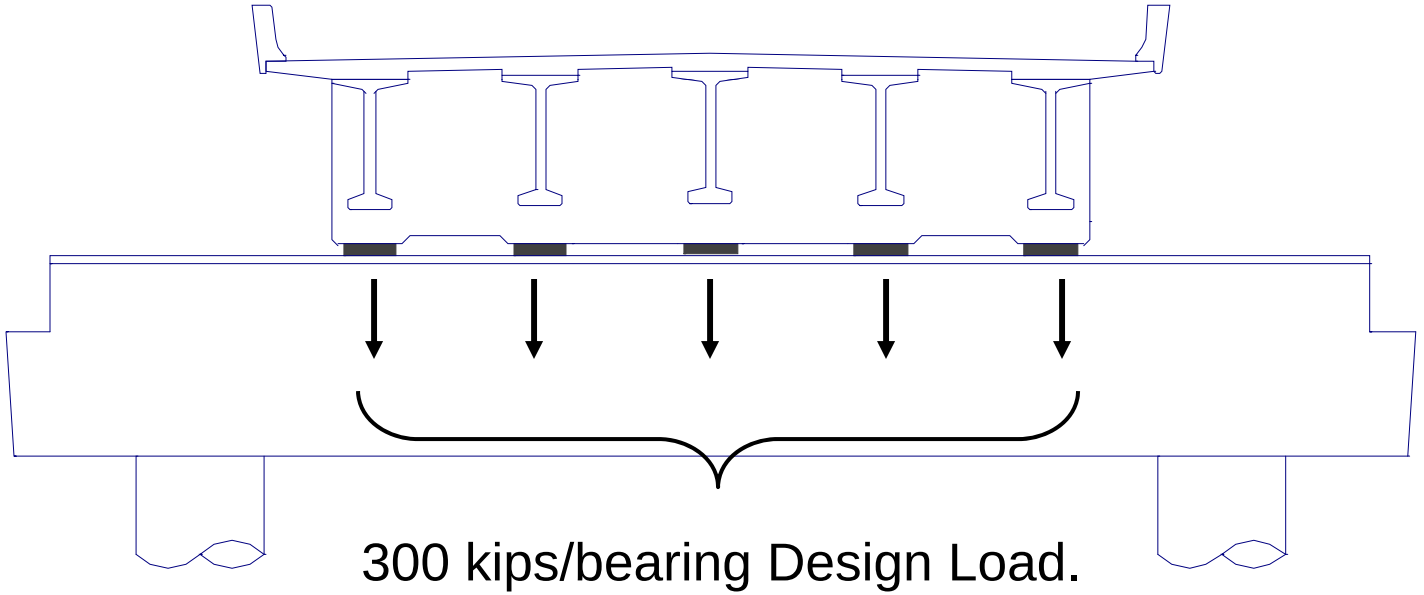
Lessons Learned

Unequal Bearing Loads



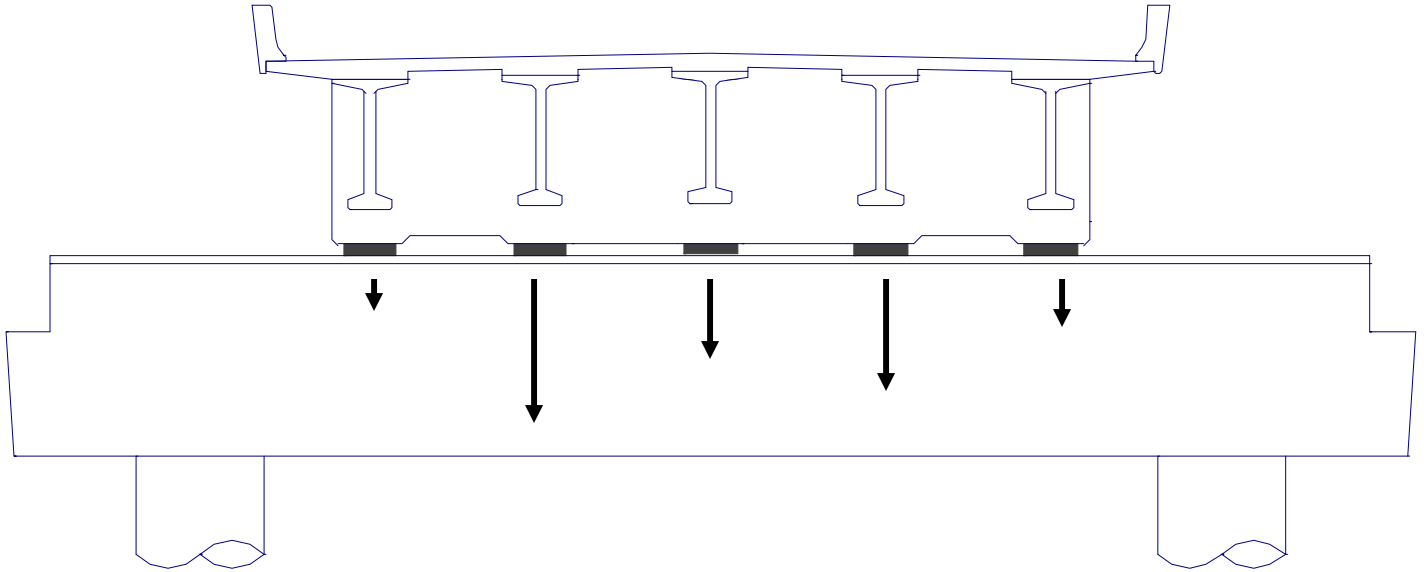
Lessons Learned

Unequal Bearing Loads



Lessons Learned

Unequal Bearing Loads



Lessons Learned

- Unequal Bearing Loads
- Jacking and shimming required

After Shimming

Design DL = 300 kips
Estimated DL = 500 kips

Prior to Shimming