Design and Construction of the SR 99 Atlantic Street Bypass

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Washington State Department of Transportation

Bridge and Structures Office

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Hyatt Regency Hotel – Bellevue, WA

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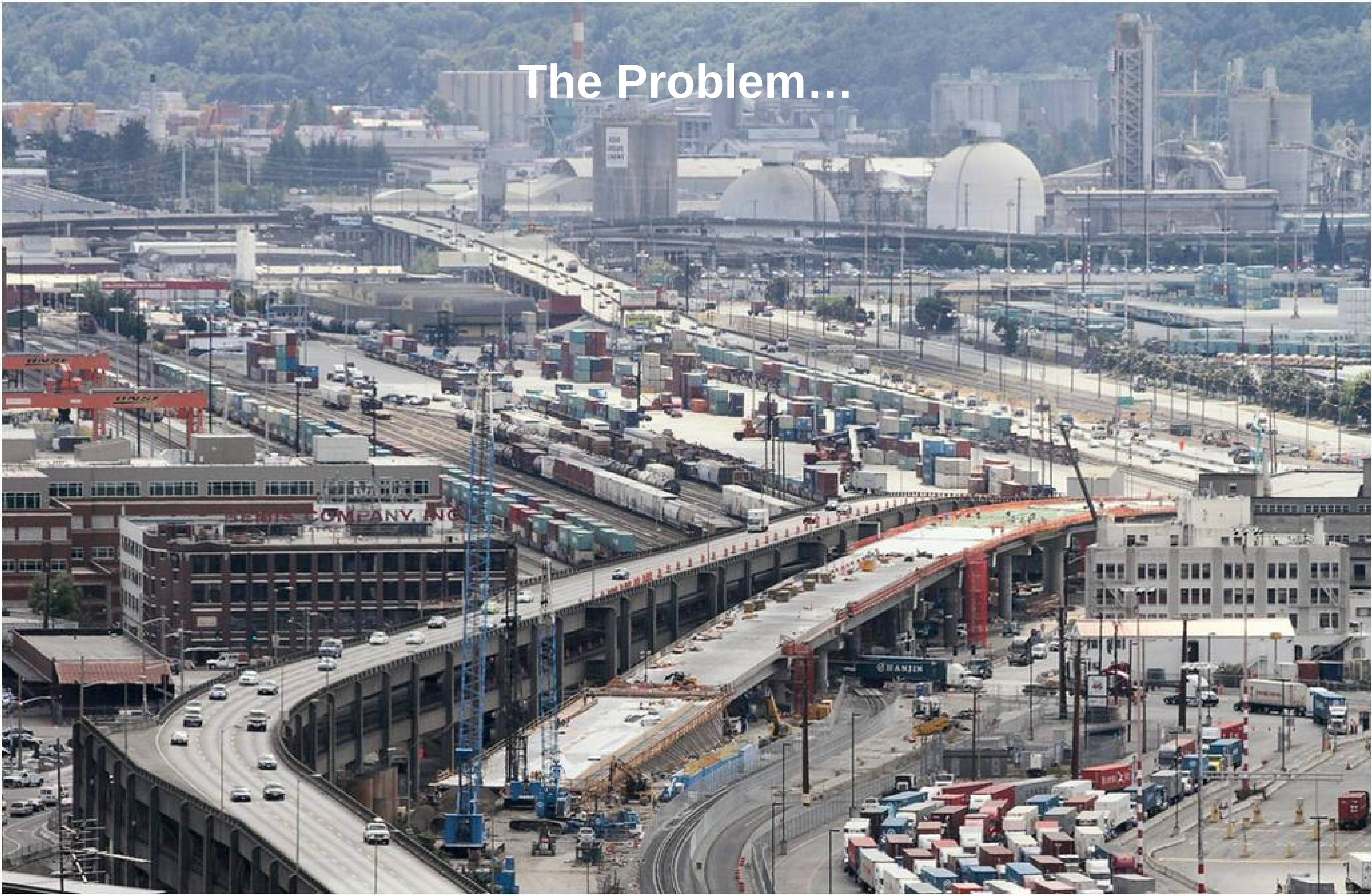
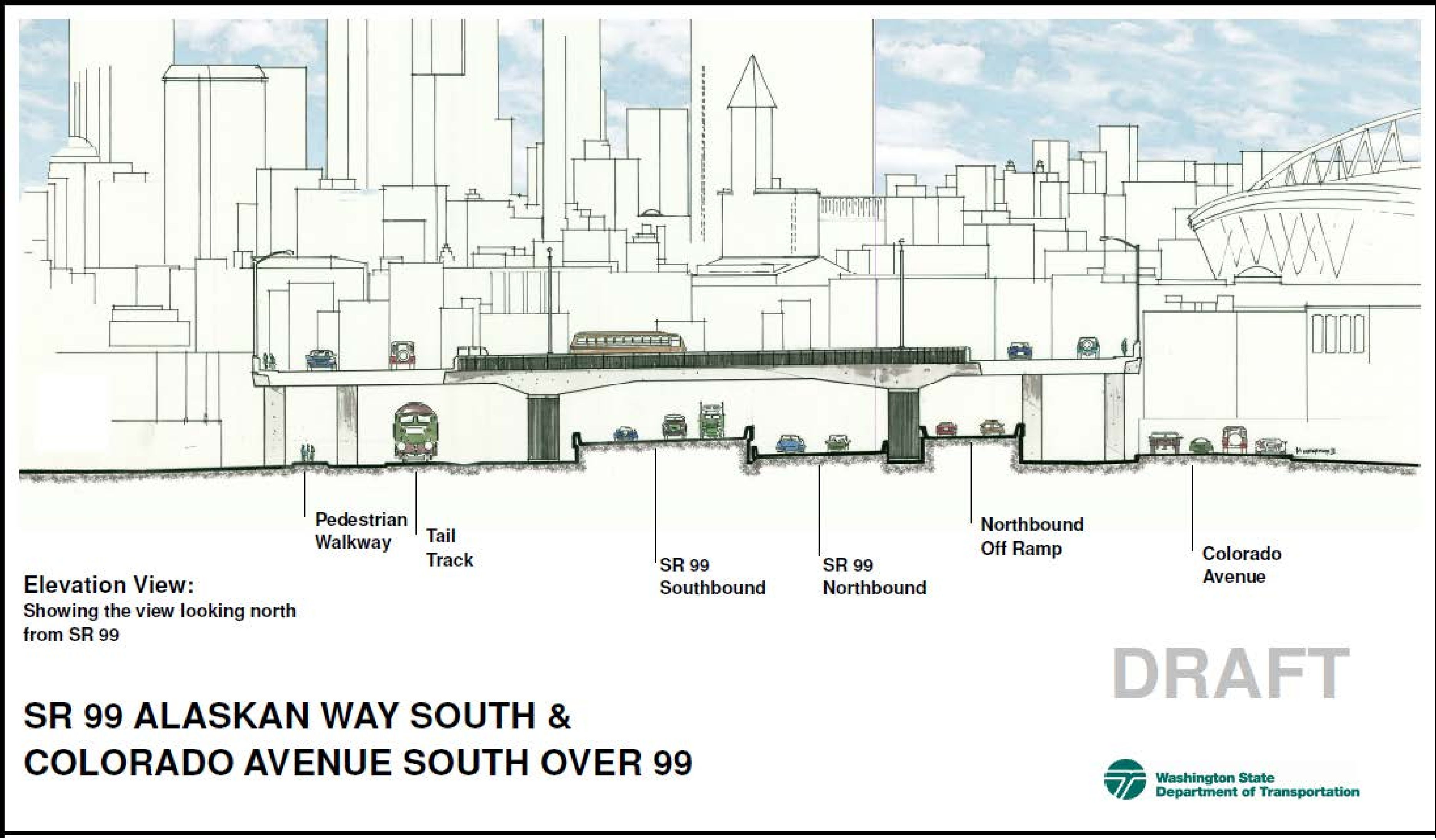
Overview

- Underpass or Overpass?
- Complex Geometry and Architecture
- Superstructure Types
- Substructure Design
- Innovative Falsework System
- Construction Sequence
- In-span Hinges
- Challenges and Lessons Learned
- Construction Photos
- Time Lapse Video of Construction
- Project Credits

The Problem…



The Solution…



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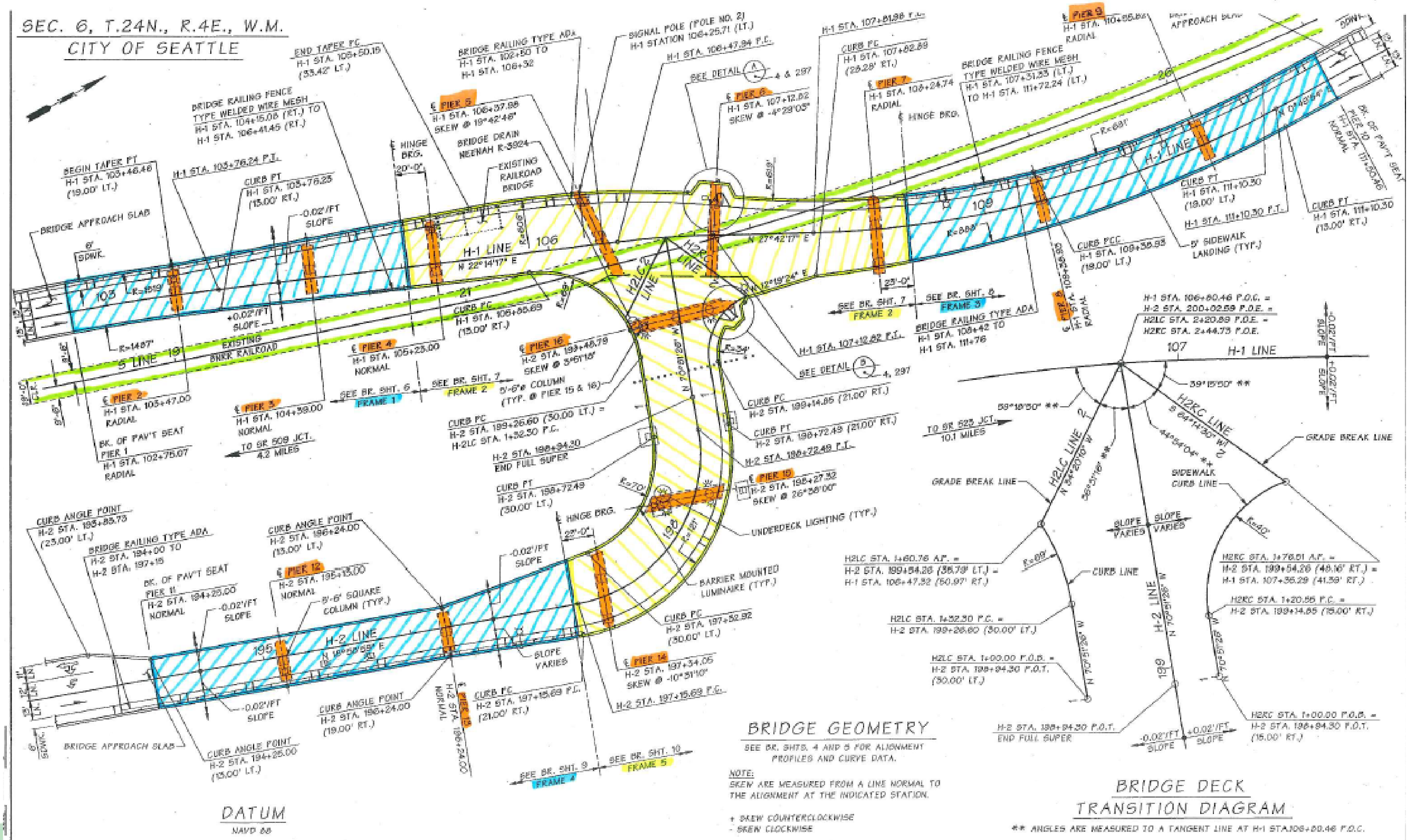
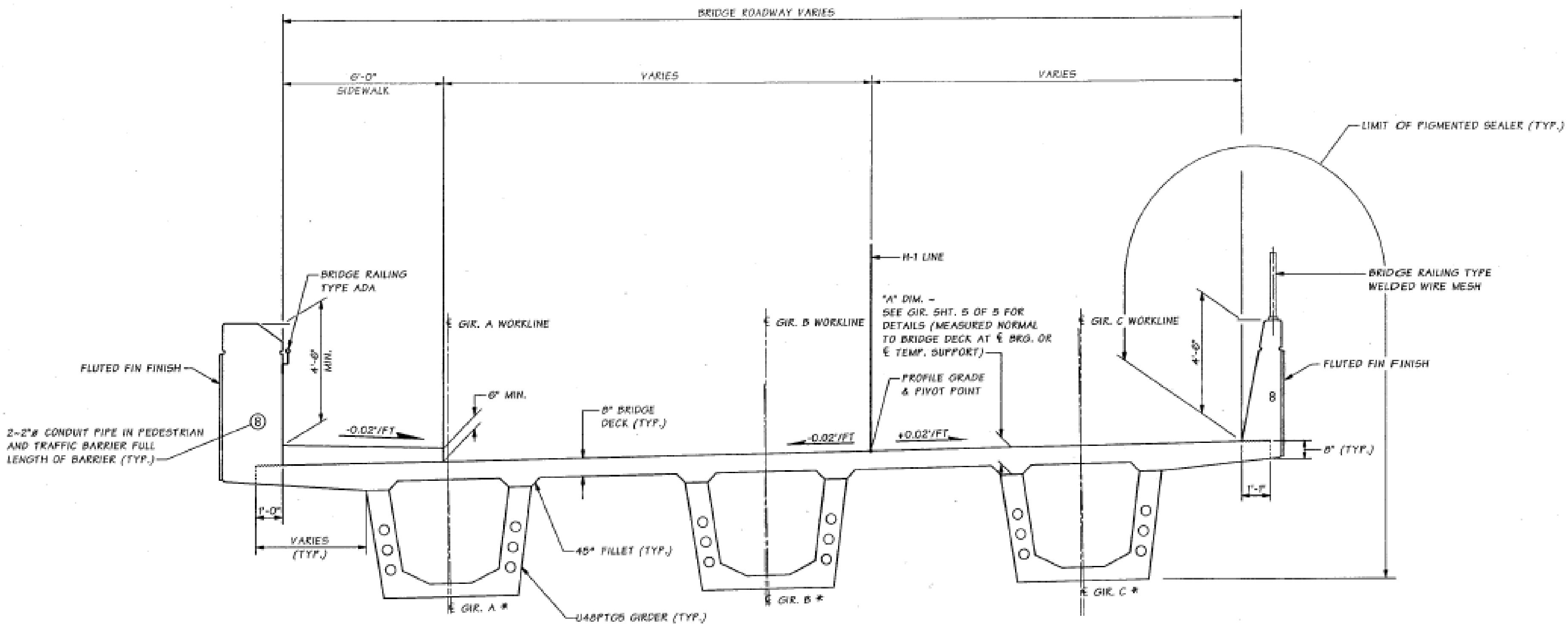
Geometry

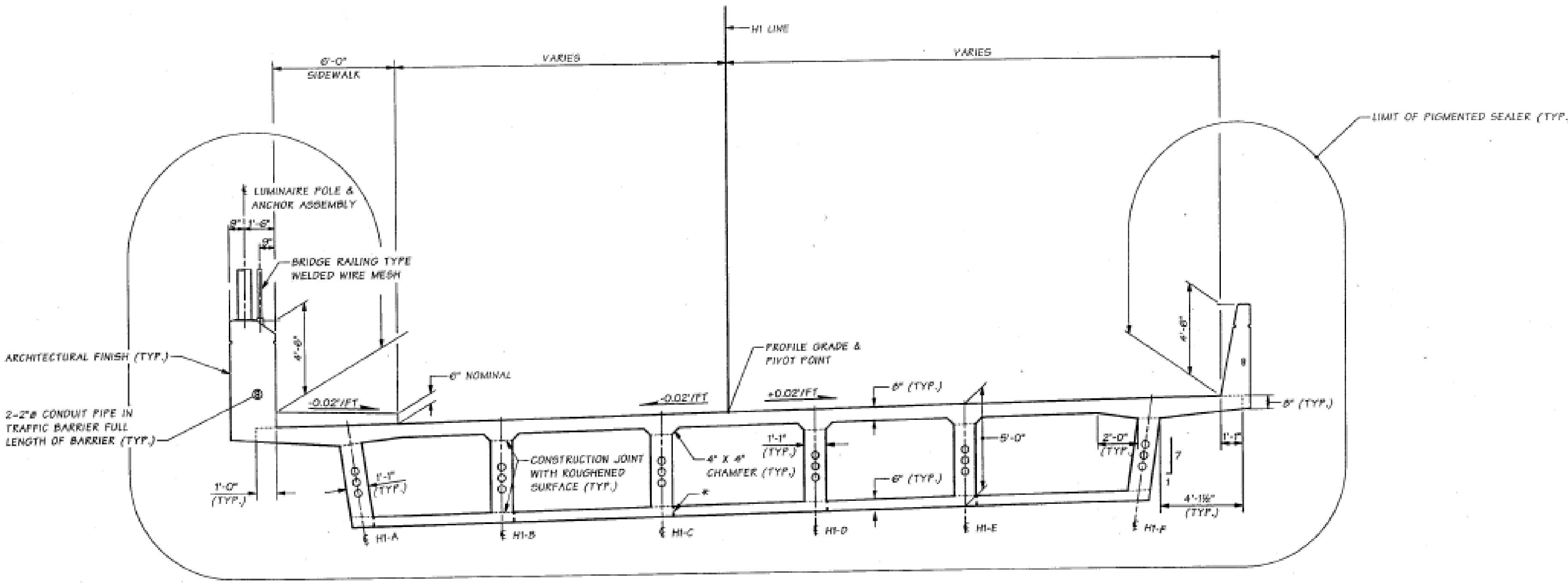


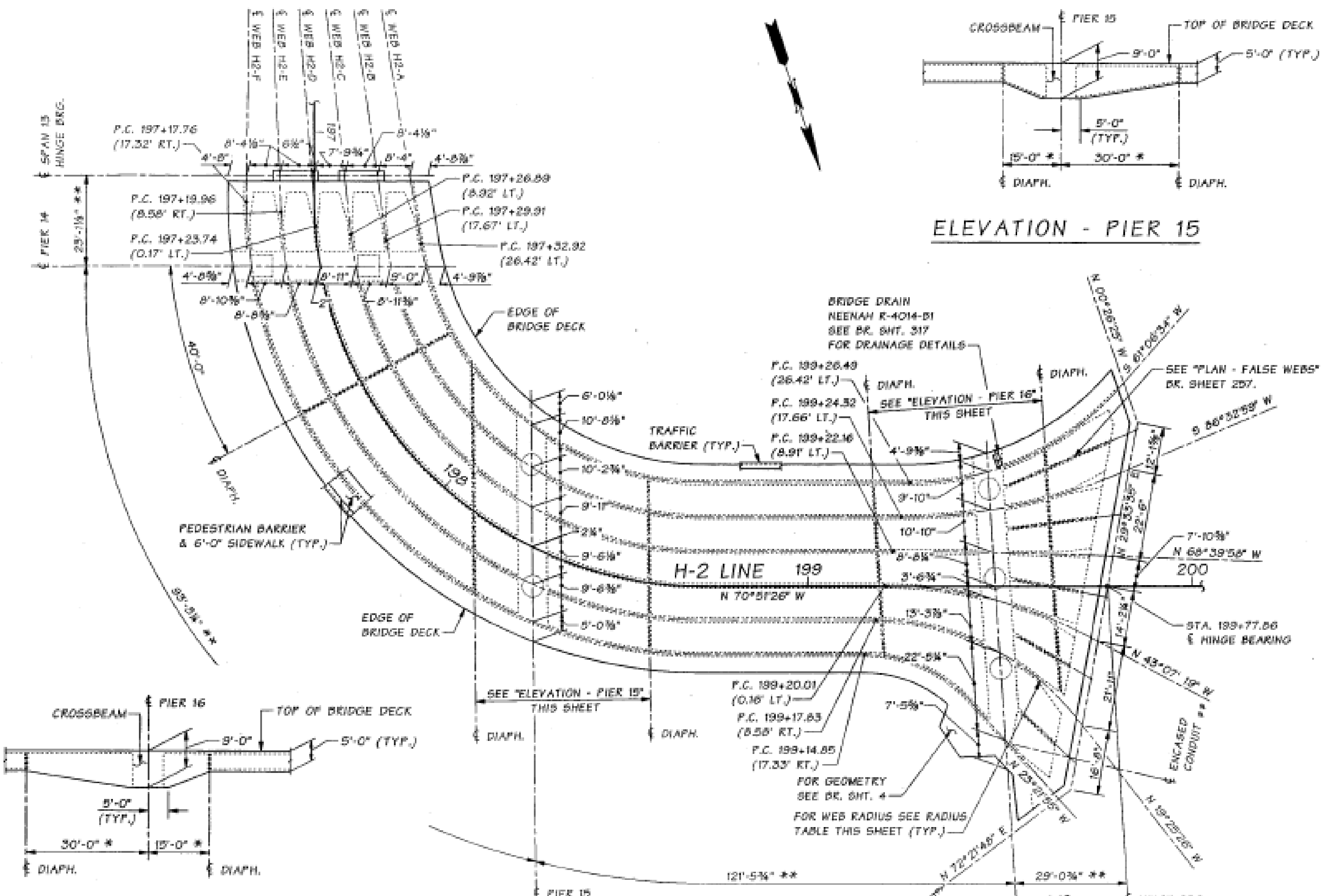
SEC. 6, T.24N., R.4E., W.M.
CITY OF SEATTLE
H-1 LINE
N 22°14'17" E
H-2 LINE
H2LC LINE
H2RC LINE
S LINE
EXISTING BNRR RAILROAD
EXISTING RAILROAD BRIDGE
BRIDGE APPROACH SLAB
℄ PIER 2
℄ PIER 3
℄ PIER 4
℄ PIER 5
℄ PIER 6
℄ PIER 7
℄ PIER 8
℄ PIER 9
℄ PIER 12
℄ PIER 13
℄ PIER 14
℄ PIER 15
℄ PIER 16
SEE BR. SHT. 6
FRAME 1
SEE BR. SHT. 7
FRAME 2
SEE BR. SHT. 8
FRAME 3
SEE BR. SHT. 9
FRAME 4
SEE BR. SHT. 10
FRAME 5
TO SR 509 JCT.
4.2 MILES
TO SR 523 JCT.
10.1 MILES
UNDERDECK LIGHTING (TYP.)
BARRIER MOUNTED LUMINAIRE (TYP.)
GRADE BREAK LINE
CURB LINE
SIDEWALK CURB LINE
BRIDGE GEOMETRY
SEE BR. SHTS. 4 AND 5 FOR ALIGNMENT PROFILES AND CURVE DATA.
NOTE:
SKEW ARE MEASURED FROM A LINE NORMAL TO THE ALIGNMENT AT THE INDICATED STATION.
+ SKEW COUNTERCLOCKWISE
- SKEW CLOCKWISE
DATUM
NAVD 88
BRIDGE DECK TRANSITION DIAGRAM
** ANGLES ARE MEASURED TO A TANGENT LINE AT H-1 STA.106+80.46 P.O.C.

Precast Tub Span Cross Section



Cast-In-Place Box Girder Section

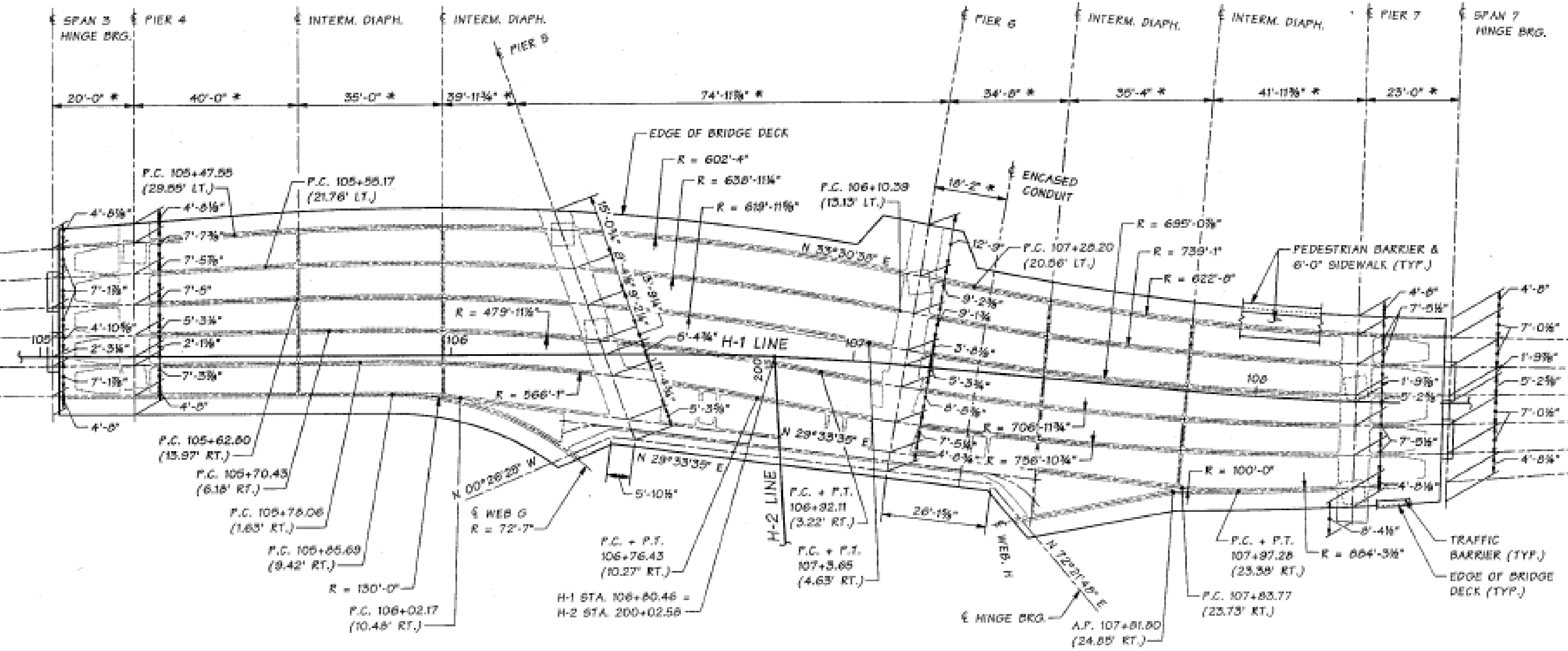




ELEVATION - PIER 16

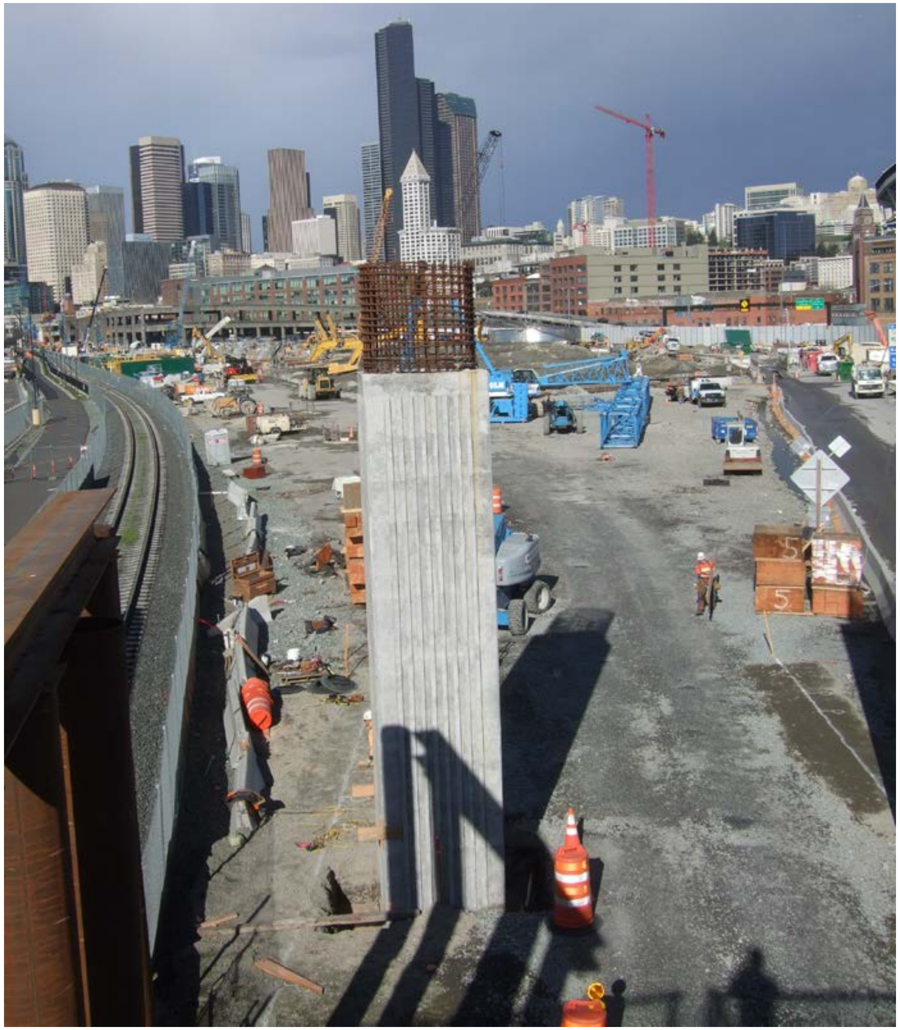
FRAMING PLAN

BEARING OF PIER 14 IS N 71°01'01" W
BEARING OF PIER 15 IS N 18°23'26" E



℄ SPAN 3 HINGE BRG.
℄ PIER 4
℄ INTERM. DIAPH.
℄ INTERM. DIAPH.
℄ PIER 5
℄ PIER 6
℄ INTERM. DIAPH.
℄ INTERM. DIAPH.
℄ PIER 7
℄ SPAN 7 HINGE BRG.
20'-0" *
40'-0" *
35'-0" *
39'-11¾" *
74'-11⅝" *
34'-8" *
35'-4" *
41'-11⅝" *
23'-0" *
EDGE OF BRIDGE DECK
R = 602'-4"
R = 638'-11¼"
R = 619'-11⅝"
P.C. 105+47.55 (29.55' LT.)
P.C. 105+55.17 (21.78' LT.)
P.C. 106+10.39 (13.13' LT.)
18'-2" *
℄ ENCASED CONDUIT
N 33°30'38" E
P.C. 107+28.20 (20.56' LT.)
R = 685'-0⅞"
R = 739'-1"
R = 622'-8"
PEDESTRIAN BARRIER & 6'-0" SIDEWALK (TYP.)
R = 479'-11¼"
H-1 LINE
105
106
107
108
200
R = 566'-1"
N 29°33'35" E
R = 706'-11¾"
R = 756'-10¼"
R = 100'-0"
N 00°26'25" W
℄ WEB G R = 72'-7"
5'-10½"
H-2 LINE
P.C. + P.T. 106+92.11 (3.22' RT.)
26'-1⅝"
℄ WEB H
N 72°21'46" E
P.C. 105+62.80 (13.97' RT.)
P.C. 105+70.43 (6.18' RT.)
P.C. 105+78.06 (1.63' RT.)
P.C. 105+85.69 (9.42' RT.)
R = 130'-0"
P.C. 106+02.17 (10.48' RT.)
P.C. + P.T. 106+76.43 (10.27' RT.)
H-1 STA. 106+80.46 = H-2 STA. 200+02.58
P.C. + P.T. 107+3.65 (4.63' RT.)
℄ HINGE BRG.
A.P. 107+81.80 (24.85' RT.)
P.C. + P.T. 107+97.28 (23.38' RT.)
P.C. 107+83.77 (23.73' RT.)
R = 884'-3½"
TRAFFIC BARRIER (TYP.)
EDGE OF BRIDGE DECK (TYP.)

Substructure

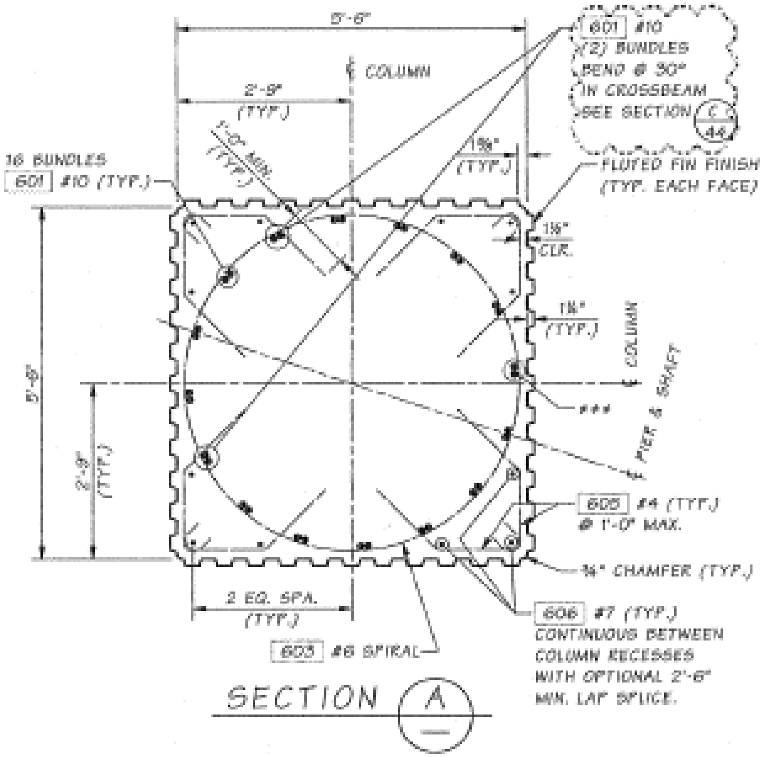


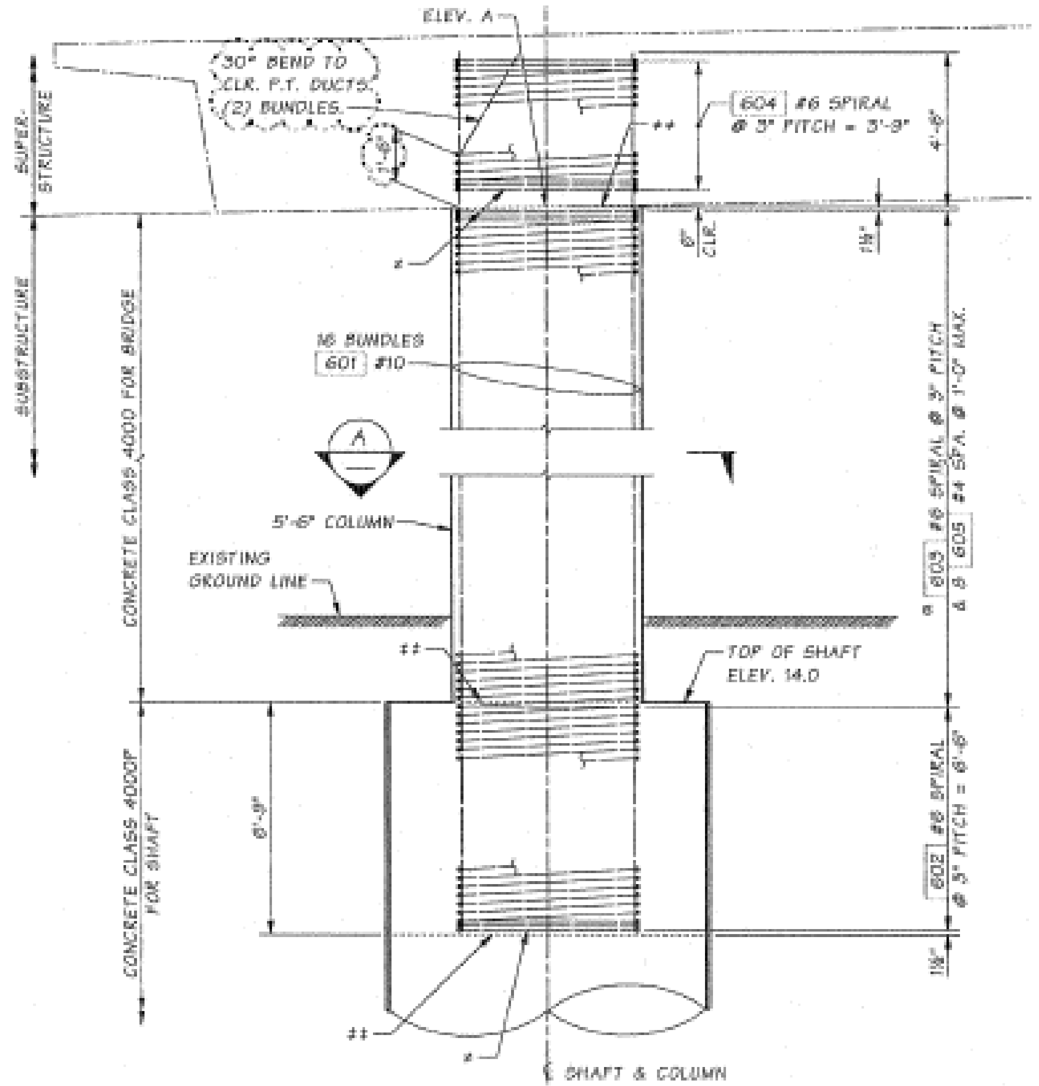
- Twenty 9’-2” diameter shafts used at all interior piers
- Six 6’-6” diameter shafts used at the three abutments
- All Piers except 15 and 16 use 5’-6” square columns
- Piers 15 and 16 use 5’-6” diameter columns; will be enclosed by precast architectural panels
- Nominal shaft capacities at the strength limit state range from 2350 tons Pier 1 to 5000 tons at Pier 16
- Falsework piles driven to an ultimate bearing resistance of 110 tons.

Seismic Modeling

- Seismic design provides an essentially elastic superstructure and a ductile substructure
- Modeling uses cracked section properties, soil/structure interaction to determine maximum column displacement demands
- Pushover analysis is performed to determine displacement capacities
- Small hinges use transverse stops and longitudinal restrainers
- Large hinge allowed to “float” on multi-rotational disc bearings

Substructure Details





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Falsework

- Falsework system utilizes steel driven piles and mudsills
- Supports are wedged at the base with wood
- Deck is built flat; Geofoam is used to form superelevation, haunches and other geometric irreegularities of the soffit
- Settlement is monitored at every stage
- Trusses used to brace exterior web

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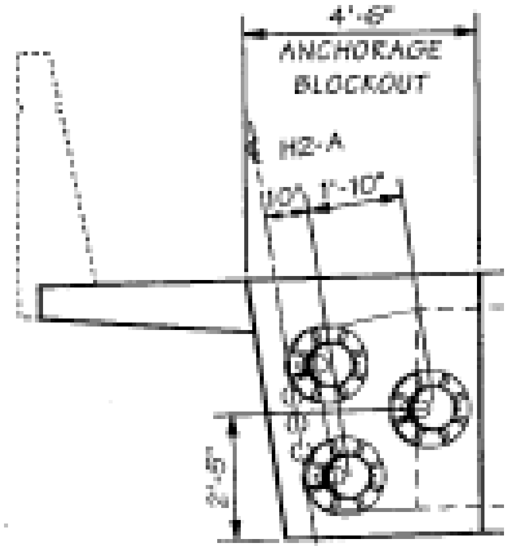
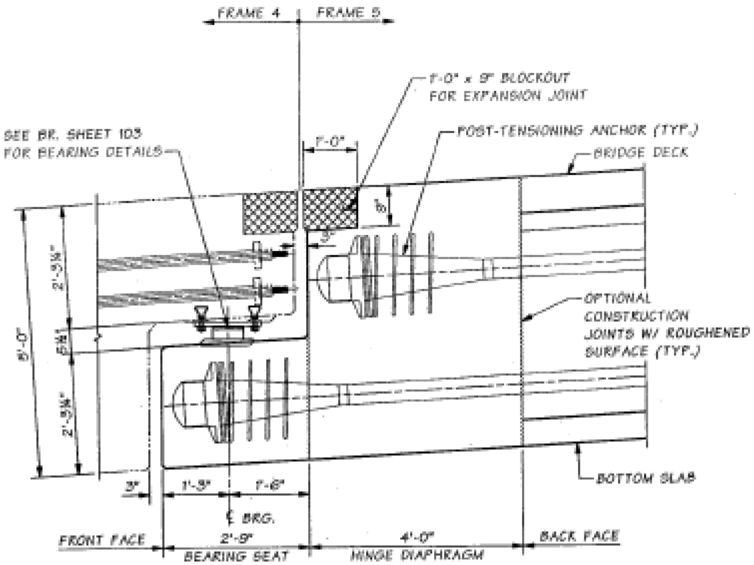
BICYCLISTS
SLOW
DOWN

Hinges

- Four in-span hinges are used between adjacent frames.
- Three "small" hinges connect the tub spans to the box girder frames.
- A large hinge near Pier 16 connects the box girder frames together.
- Designed for PT anchorage, load transfer, future bearing replacement.
- Due to the shallow depth, this became the most congested areas to construct.
- Due to deviation of the tendons at tight radii, a large amount of steel was required to confine the tendons.



Small Hinge Design



- Tub spans are supported by the box girder bearing seat. Seats are fully post-tensioned.
- Inspection and replacement are allowed by discontinuous design of seats.
- Size of seats allow load distribution and room for jacks to allow for bearing replacement.
- Lateral stops engage the top tongue of the tub spans.
- Sliding fabric pad bearings are used.
- Longitudinal restrainers engage the hinge diaphragms.

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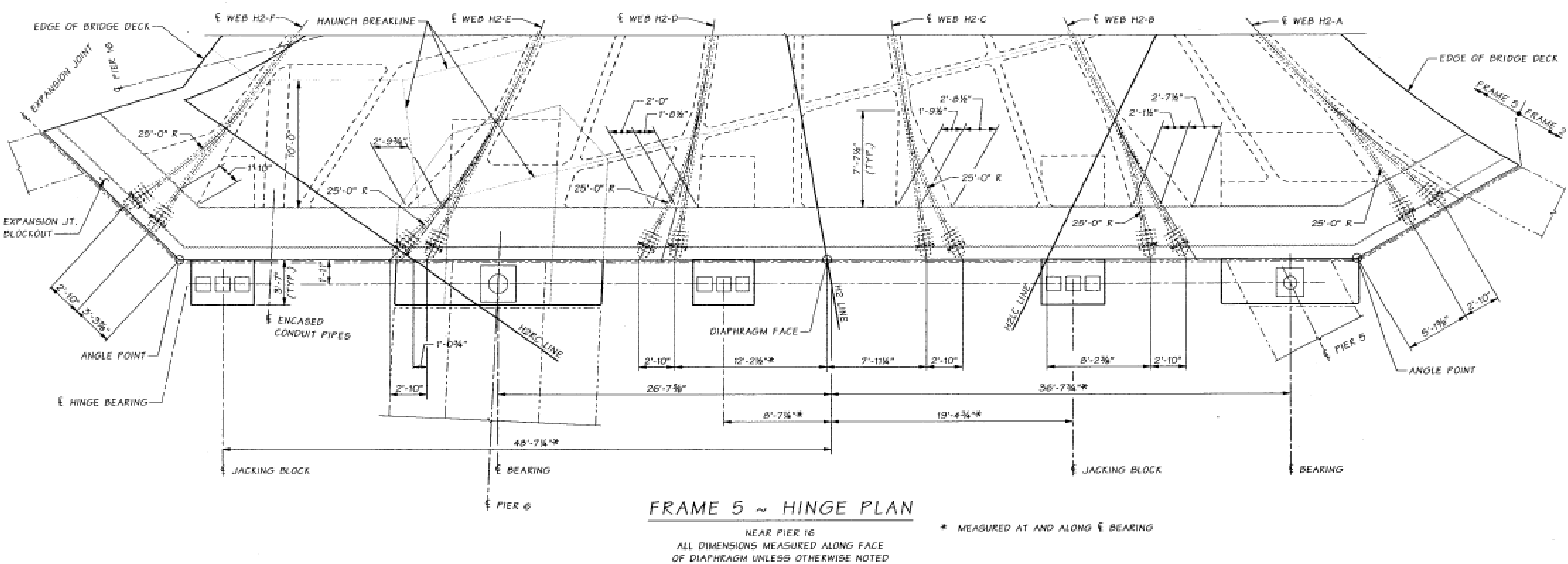
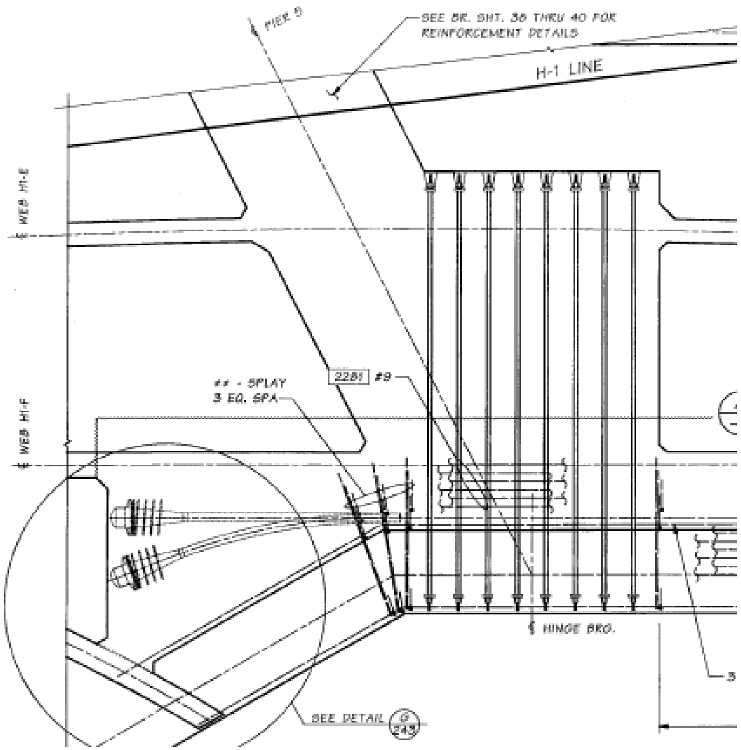


- Piers 5 and 6 from Frame 2 are supported by the Pier 16 hinge diaphragm
- Both bearing seats are post-tensioned with bar tendons for a fully post-tensioned design
- Disc bearings are used at each Pier to allow the two frames to move independently
- Three jacking blocks are provided for future bearing replacement

Large Hinge



- Bearing ends of Piers 5 and 6 are post-tensioned as well.
- Busy details with two way post-tensioning and crossbeam reinforcement.
- Due to limited width, the Frame 2 side diaphragm is concentrically post-tensioned.

Challenges

- Multiple design challenges
  1. Shallow Box
  2. High curvature
  3. Inflexible foundation plan
  4. Short timeline
- Construction challenges
  1. PT tendon adjustments
  2. Adjacent projects
  3. Aggressive schedule


6/6/2013


5/16/2013


8/1/2013


8/1/2013


8/1/2013

Design Credits

- Tim Moore – Design Supervisor
- Eric Schultz – Lead Designer
- Munindra Talukdar – Substructure Design
- Nick Rodda – CIP PT Box Design
- Eric Schultz
- Jed Bingle
- Michael Bressan

  } Precast Tub Design

- Elena Gunis
- Diane Avery
- Dan Puryear
- Adam Evans
- Justin Nettle

  } Drafting Support

- Lou Tran – PT Box Checking
- Anthony Mizumori – Precast Fascia Panels

Construction Credits

- Paul Johnson – WSDOT Project Engineer
- Kevin Hepler
- Adam Fisher
- Brandon Humphrey

(Kevin Hepler, Adam Fisher, Brandon Humphrey) WSDOT Inspectors

- Guy F. Atkinson – Prime Contractor
- Gerdau – Sub-Contractor (Rebar)
- Schwager Davis – Sub-Contractor (Post-Tensioning)

- Engineer's Estimate - $35.6 Million
- Low Bidder - $29.4 Million (17.6% Below)