WB-207 & WB-208 Bridge Replacement Project at M.P. 12.63 & 12.67 in Beaver County

ABCD Susquehanna Chapter
2015 Technical Conference

WB-207 & WB-208 Bridge Replacement Project

By:

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CDR Maguire Inc.

September 3, 2015

PROJECT LOCATION

Project Background

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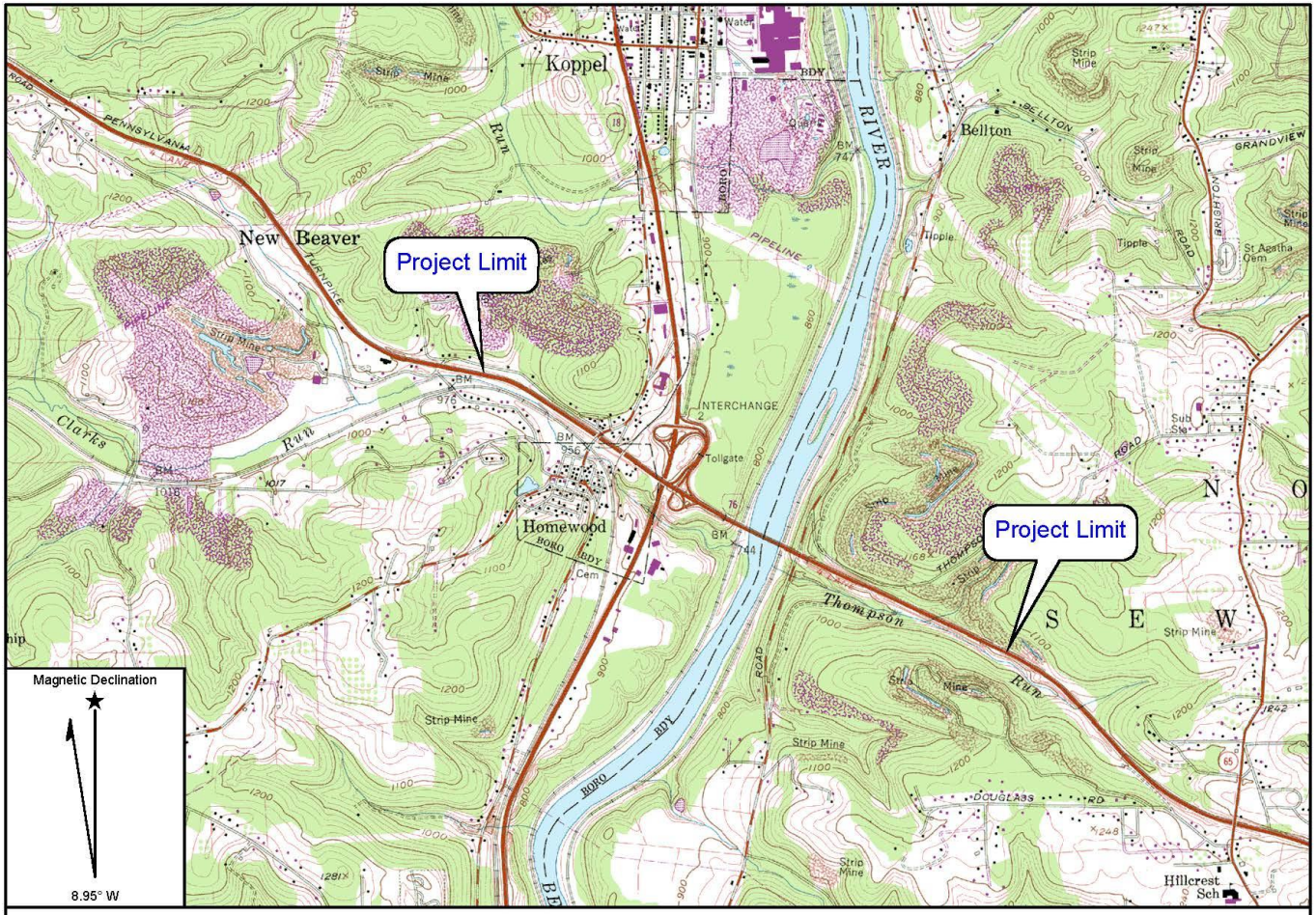
WB-207 & WB-208 Bridge Replacement Project

PROJECT LOCATION



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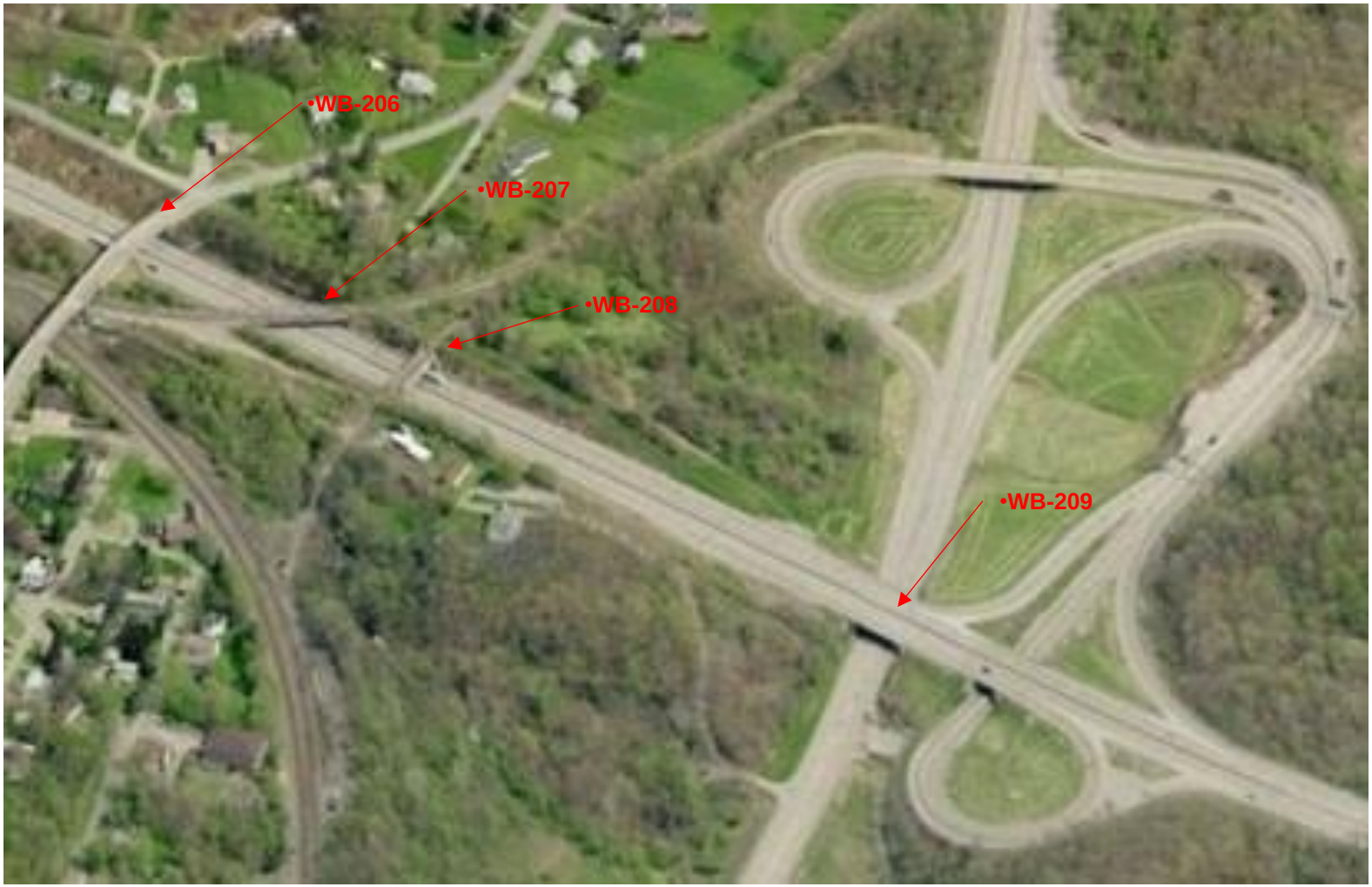
WB-207 & WB-208 Bridge Replacement Project

PROJECT LOCATION



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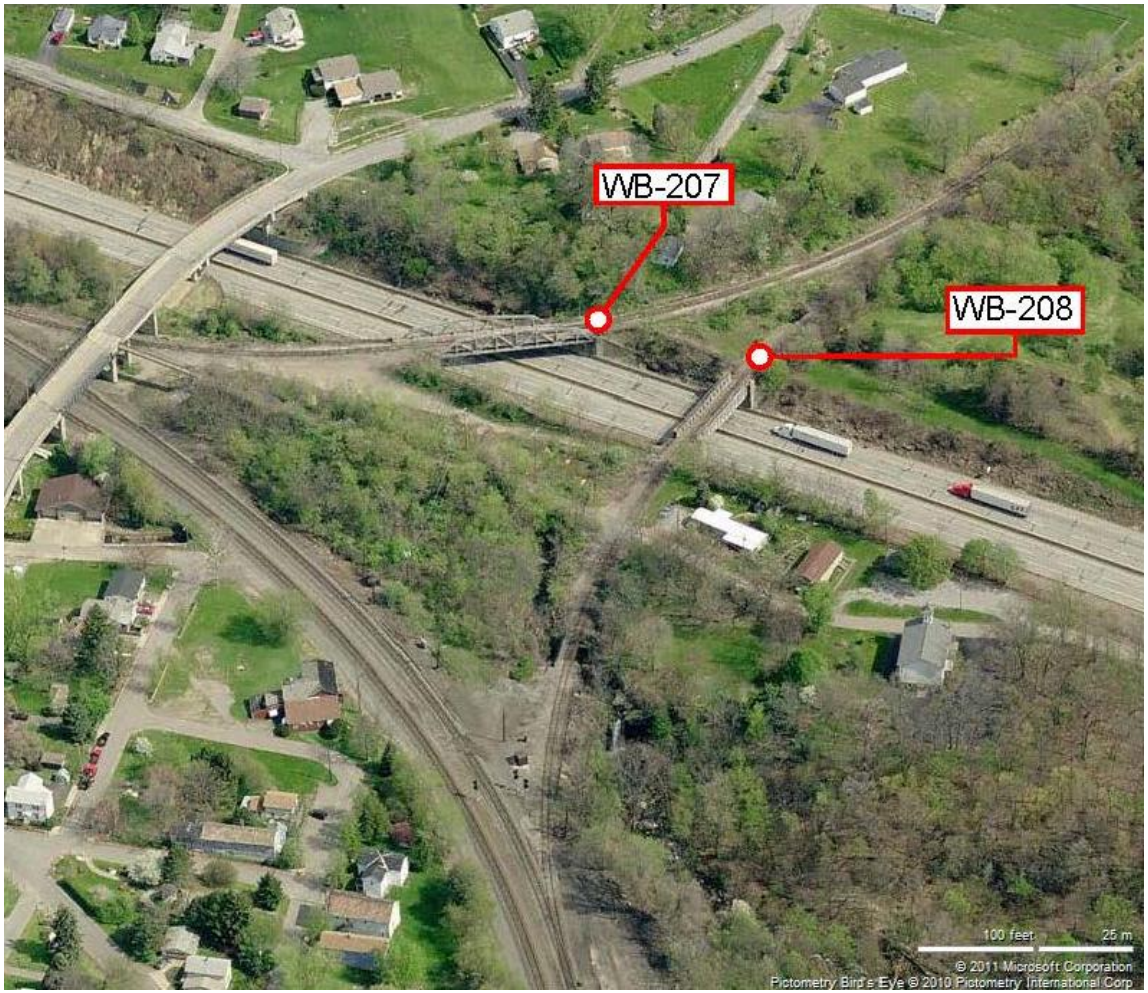
WB-207 & WB-208 Bridge Replacement Project

PROJECT LOCATION



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WB-207 & WB-208 Bridge Replacement Project

PROJECT LOCATION

Existing WB-207 Bridge:
Pony Truss
137’-6” c/c brgs.
24’-0” c/c truss chords
18’-6” max. truss height
36°59’11” skew
Dc = 4°45’45”

Existing WB-208 Bridge:
Thru-Girder
82’-8” c/c brgs.
20’-4” c/c girders
10’-0 ½” web depth
90° skew
Dc = 5°40’00”

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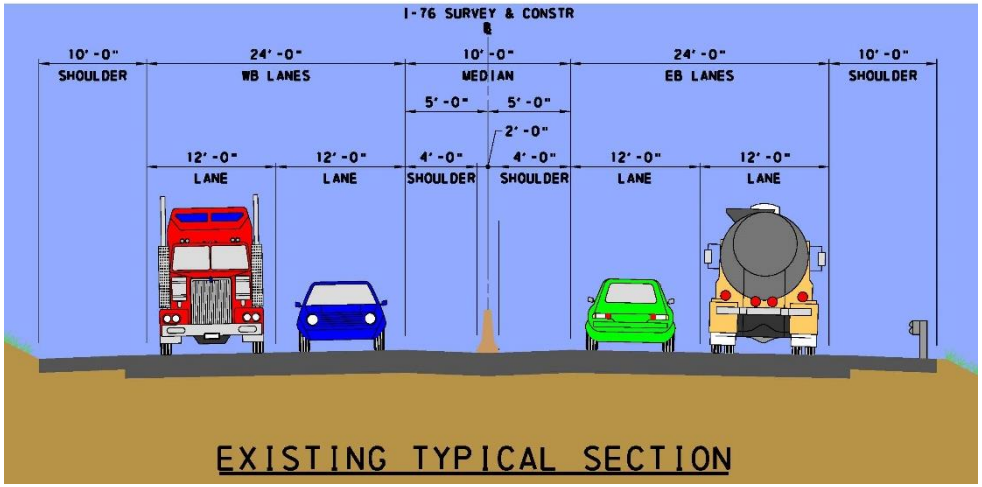
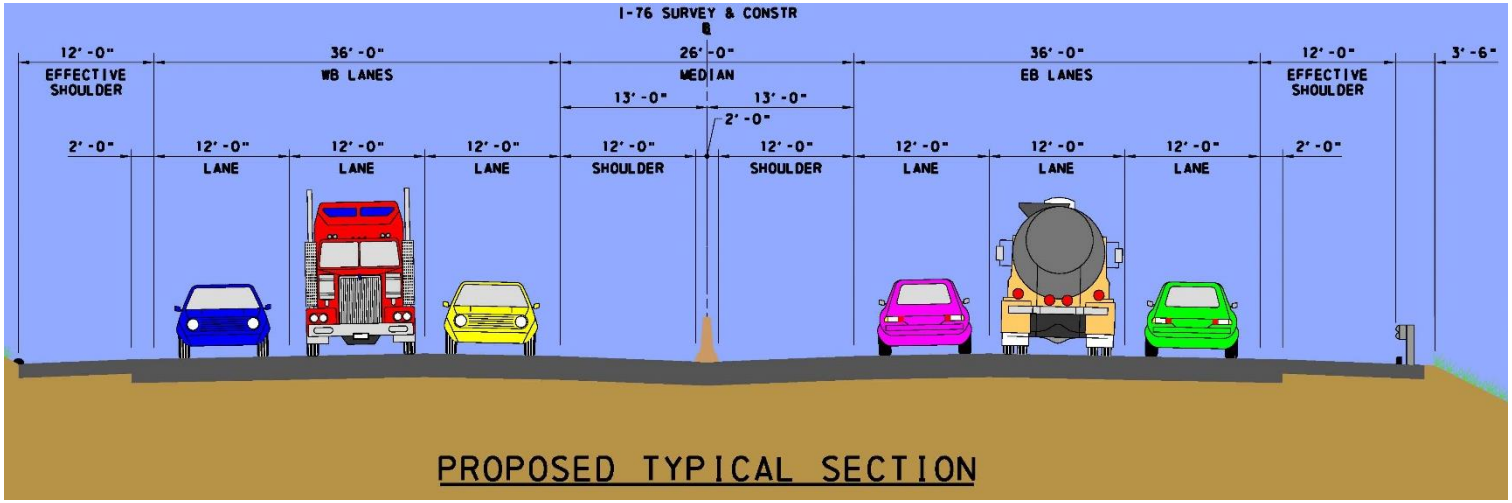
WB-207 & WB-208 Bridge Replacement Project

DESIGN GEOMETRY



EXISTING TYPICAL SECTION



PROPOSED TYPICAL SECTION

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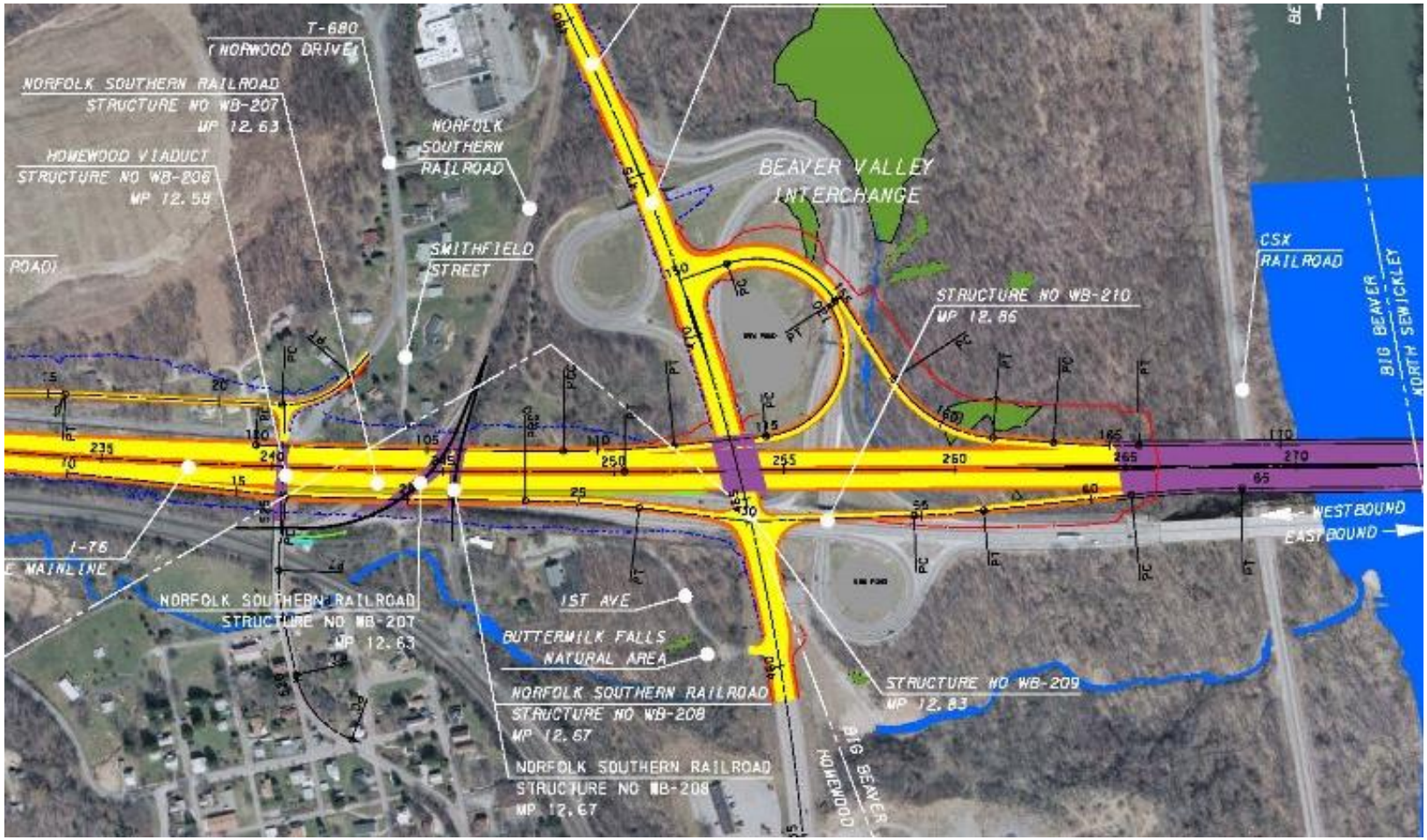
WB-207 & WB-208 Bridge Replacement Project

DESIGN GEOMETRY



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WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Alignment Alternatives:

- **Eliminate one of the Wye legs**
- **Replace the WB-207 & WB-208 bridges on existing alignments**
- **Use a single bridge for combined WB-207 & WB-208 tracks**
- **Relocate the WB-207 bridge between the existing structures and maintain the WB-208 alignment**

Note:

- **Steel stringers cannot be used for WB-207 & WB-208 bridges due to substandard vertical clearance at railroad bridges & SR 0018**

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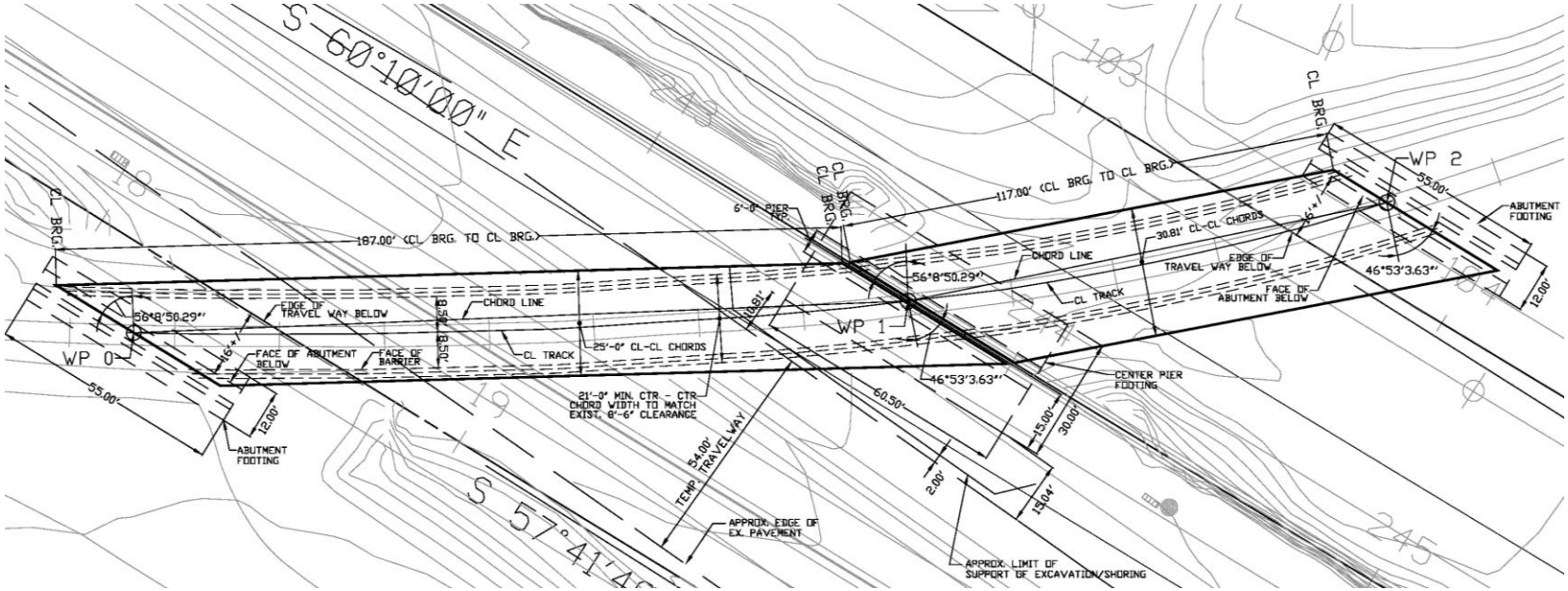
Eliminate one of the wye legs:

"No."

WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Replace the WB-207 & WB-208 bridges on existing alignments:



- **WB-207 Spans = 171', 132'**
- **Design Dc = 6°00'00"**
- **Truss required**

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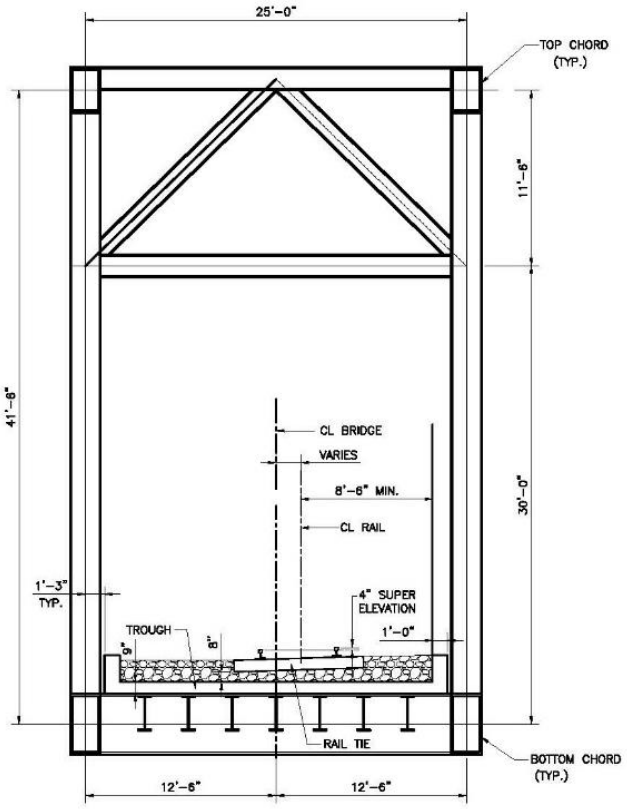
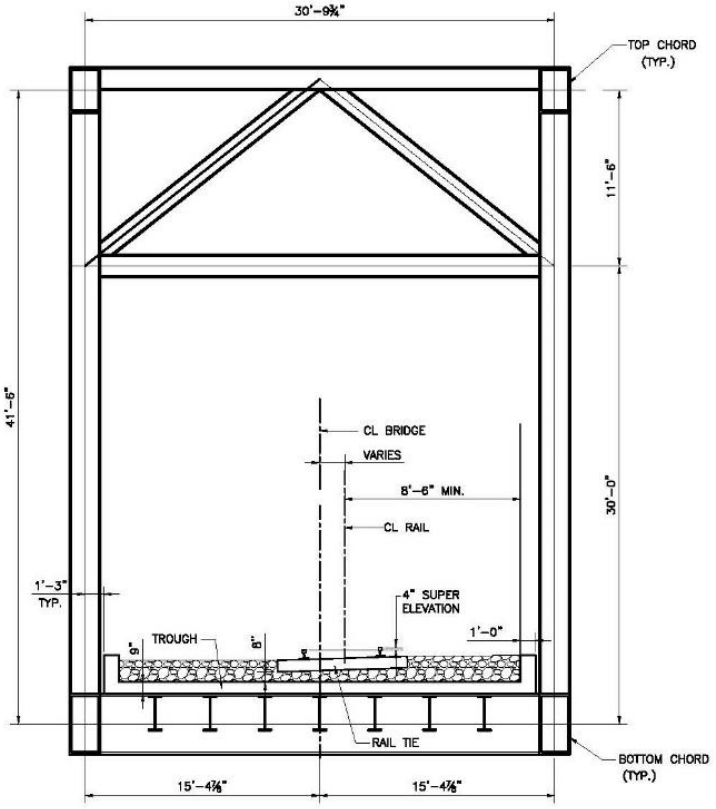
WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Replace the WB-207 & WB-208 bridges on existing alignments:



(SPAN 1)



(SPAN 2)

- **Truss height = 41’-6”**
- **C/C chords = 25’-0”, 30’-9 ¾”**

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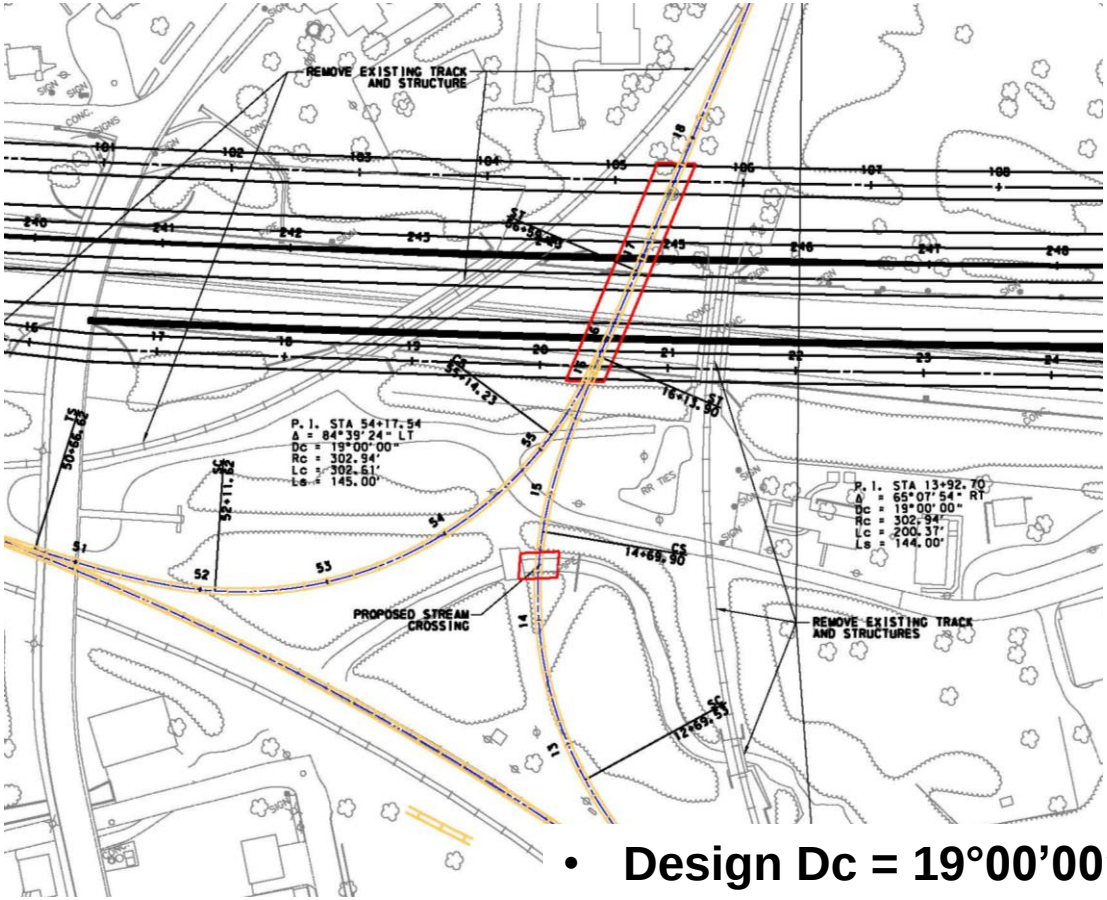
WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Use a single bridge for combined WB-207 & WB-208 tracks:



- **Design Dc = 19°00’00”**
- **Turnout located near bridge**

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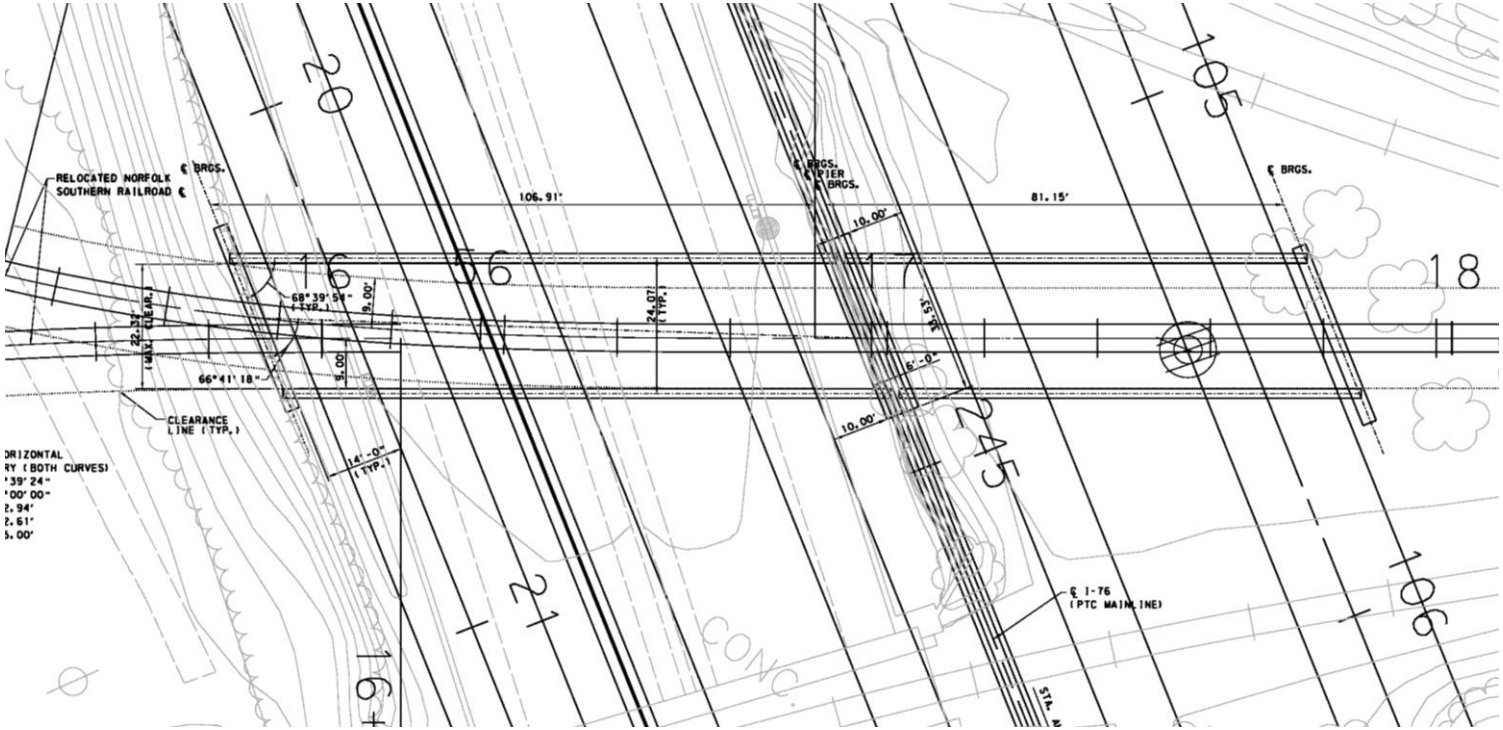
WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Use a single bridge for combined WB-207 & WB-208 tracks:



- **Design Dc = 19°00’00” or less**
- **Turnout Located On/Near Bridge**
- **Spans = 107’, 81’**

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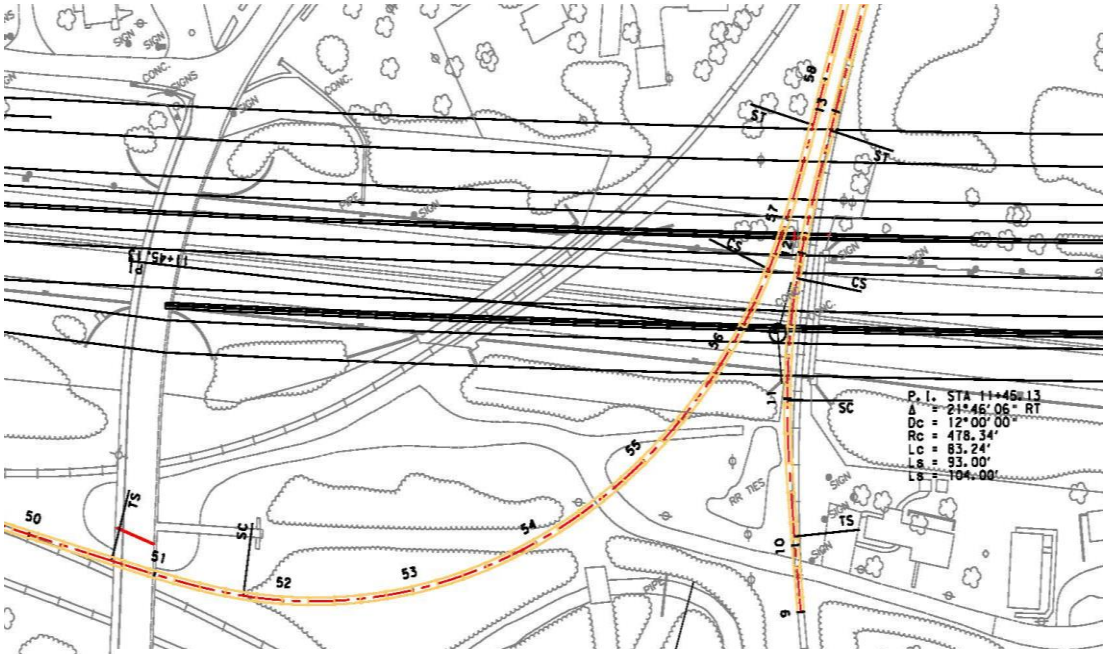
WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Use a single bridge for combined WB-207 & WB-208 tracks:



- **Design Dc = 15°00’00” (WB-207)**
- **Design Dc = 12°00’00” (WB-208)**
- **Truss or large membered thru-girders required due to width (vertical clearance an issue)**
- **WB-208 track relocation requires new bridge over Clarks Run at the south approach**

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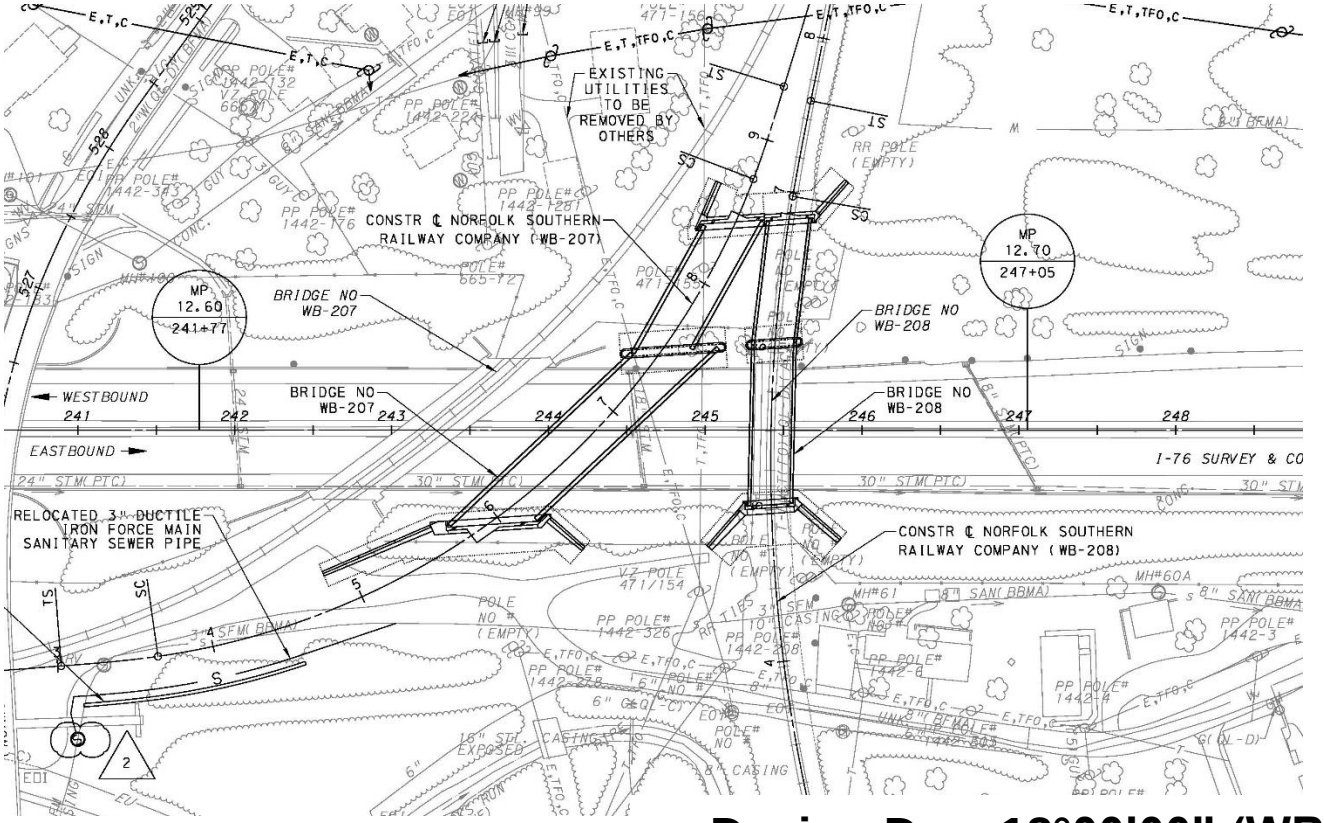
WB-207 & WB-208 Bridge Replacement Project

ALTERNATIVES ANALYSIS

Relocate the WB-207 bridge between the existing structures and maintain the WB-208 alignment:



- **Design Dc = 12°00’00” (WB-207)**
- **Design Dc = 5°40’00” (WB-208)**
- **Thru-girder bridges**

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Design

WB-207 & WB-208 Bridge Replacement Project

DESIGN CRITERIA

Norfolk Southern Design Requirements:

- **Dc max. limited to 12°**
- **Use 10 MPH to determine track superelevation**
- **AREMA clearance envelope**
- **50 ksi steel vs. 36 ksi steel**
- **Provide abutment RF normal to tracks for approach slab**
- **All connections must be bolted**
- **Use ballasted deck plate (cannot use composite properties for deflection calculations)**
- **Cross slope not required for deck ballast pan drainage**
- **Drainage must flow to PTC system**
- **Cold spray applied elastomeric waterproofing**
- **141# rail section**

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WB-207 & WB-208 Bridge Replacement Project

DESIGN CRITERIA

Design Criteria:

- **AREMA Manual for Railway Engineering, 2012**
- **Norfolk Southern Guidelines for Design of Grade Separation Structures, 2004**
- **PennDOT DM-4, September 2007 Edition**
- **AASHTO Standard Specifications for Highway Bridges, 16th Ed.**
- **Design is in accordance with the ASD Method**
- **Design Live Loading is the Cooper E-80 or Alternative Live Load on 4 Axles**

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WB-207 & WB-208 Bridge Replacement Project

DESIGN CRITERIA

Design Issues:

- **Track grades are in opposite directions**
- **Bearing fixity is reversed between the two bridges**
- **Location of girders at the north abutment**
- **Additional span lengths due to 6- lane I-76 typical section, plus the addition of the EB decel. and WB accel. lanes**
- **Interim vertical clearance over I-76**
- **Sharp skew**
- **Track curvature and rail superelevation**
- **All bolted connections- minimize welds**
- **Geometry and fitment of girders, floorbeams, and misc. steel**
- **Constructability**

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WB-207 & WB-208 Bridge Replacement Project

Proposed WB-207 Bridge:

- **Spans: 156’-7 ¾”, 90’-2 1/8”**
- **Skews: 39°21’56”, 56°57’13”**
- **C/C Girder Spacing: 35’-0”, 31’-4”**
- **Floorbeams: W36x194 and W36x160 @ 2’-11” +/-**
- **Web: 132” x 1 ¼” max.**
- **Top Flange: 28” x 3 ¼” max.**
- **Bottom Flange: 32” x 4” max.**

DESIGN

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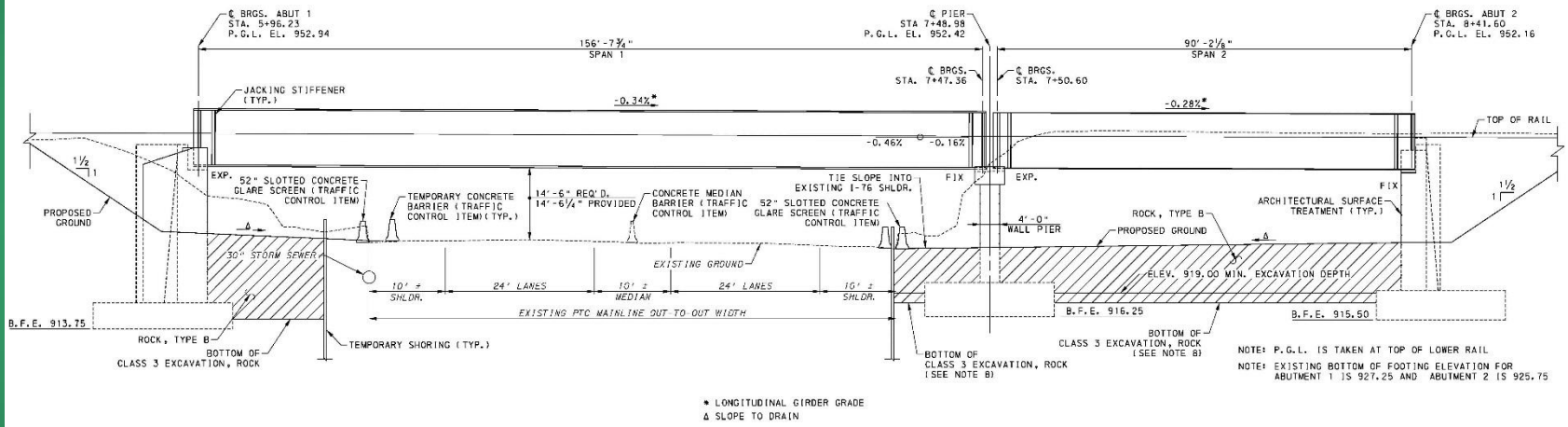
WB-207 & WB-208 Bridge Replacement Project



WB-207 Elevation

DESIGN

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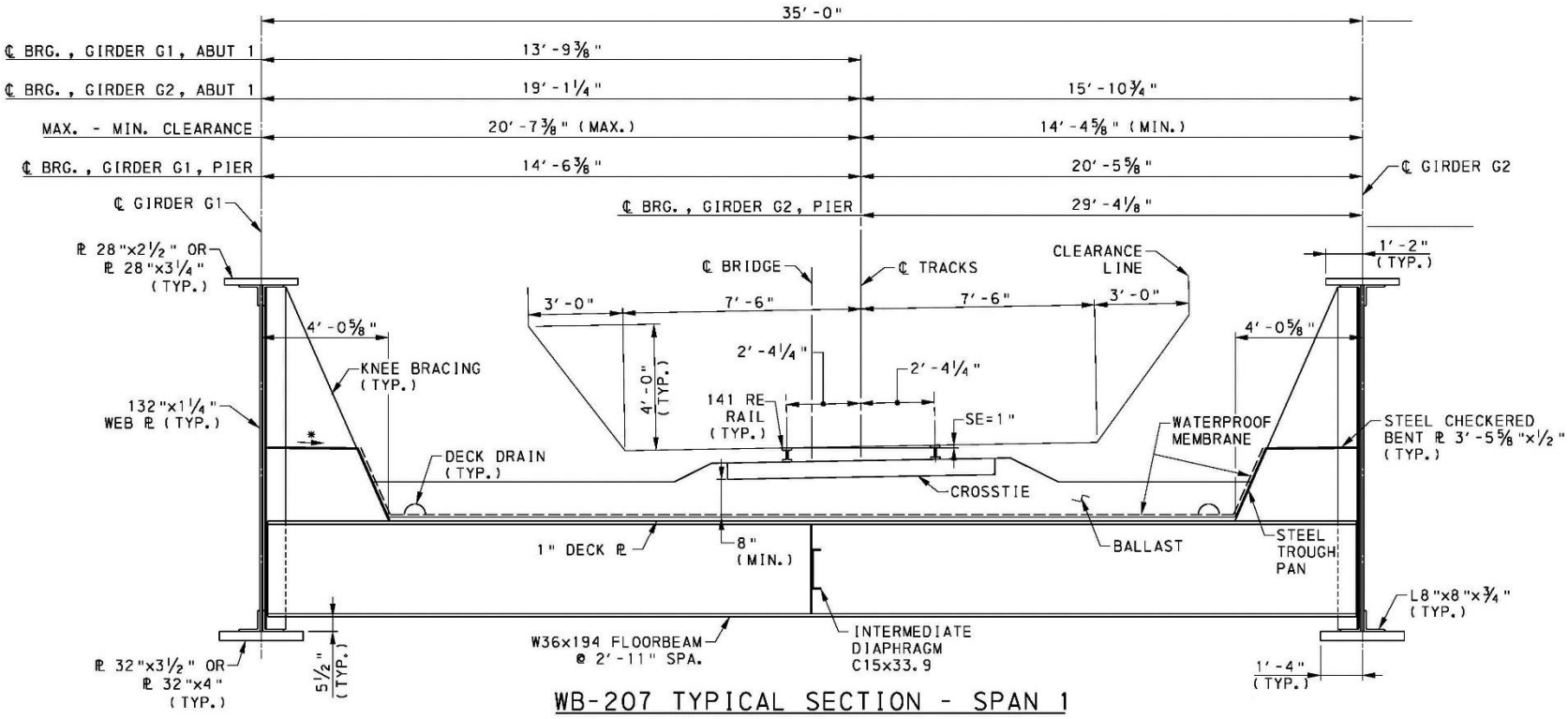
WB-207 & WB-208 Bridge Replacement Project

WB-207 Span 1 Typical Section (Span 2 Similar)



WB-207 TYPICAL SECTION - SPAN 1

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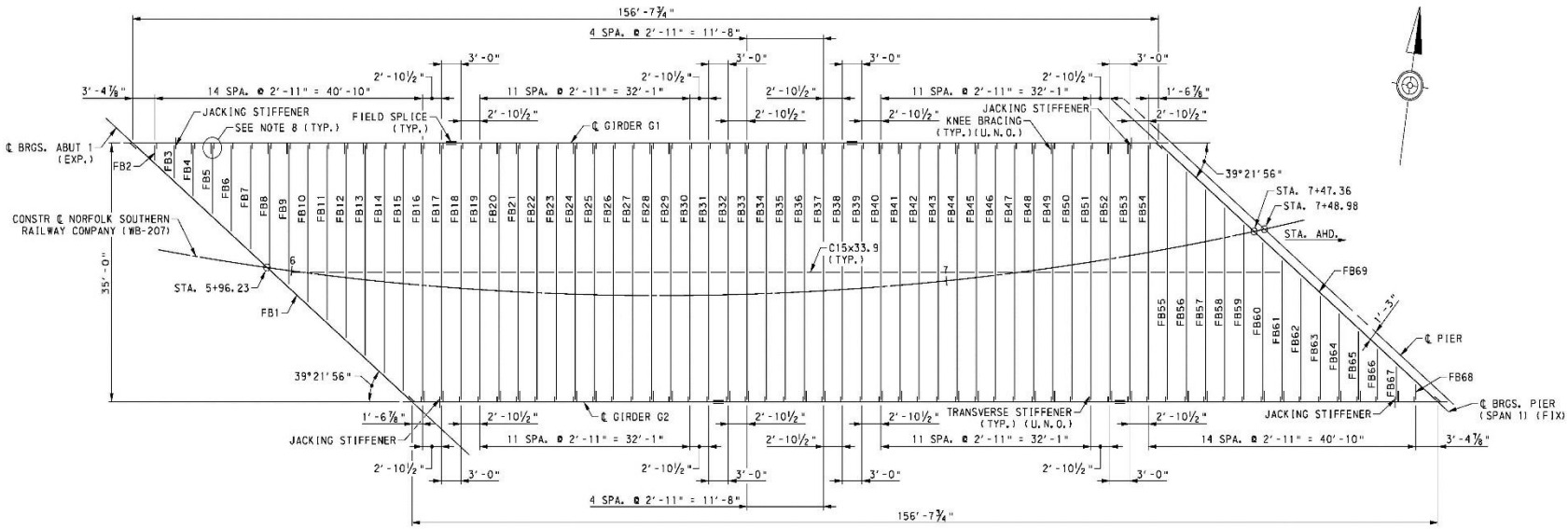
WB-207 & WB-208 Bridge Replacement Project

WB-207 Span 1 Framing Plan



WB-207 FRAMING PLAN - SPAN 1

DESIGN

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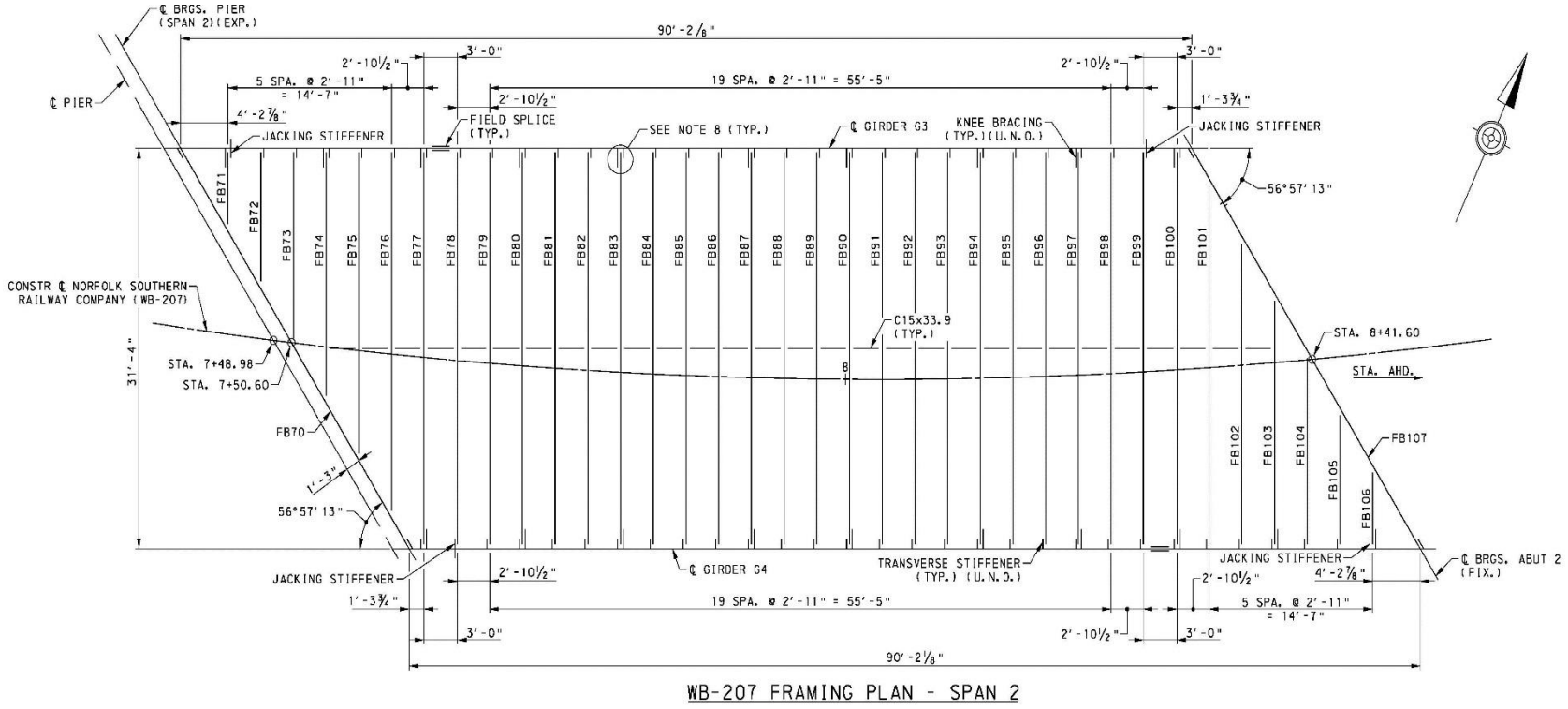
WB-207 & WB-208 Bridge Replacement Project

WB-207 Span 2 Framing Plan



WB-207 FRAMING PLAN - SPAN 2

DESIGN

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WB-207 & WB-208 Bridge Replacement Project

Proposed WB-208 Bridge:

- **Spans: 99’-8 1/8”, 76’-8”**
- **Skews: 84°40’38”, 79°03’33”**
- **C/C Girder Spacing: 26’-8”, 26’-6”**
- **Floorbeams: W33x141 @ 2’-11” +/-**
- **Web: 99” x ¾” max.**
- **Top Flange: 20” x 2 ¼” max.**
- **Bottom Flange: 24” x 2 ½” max.**

DESIGN

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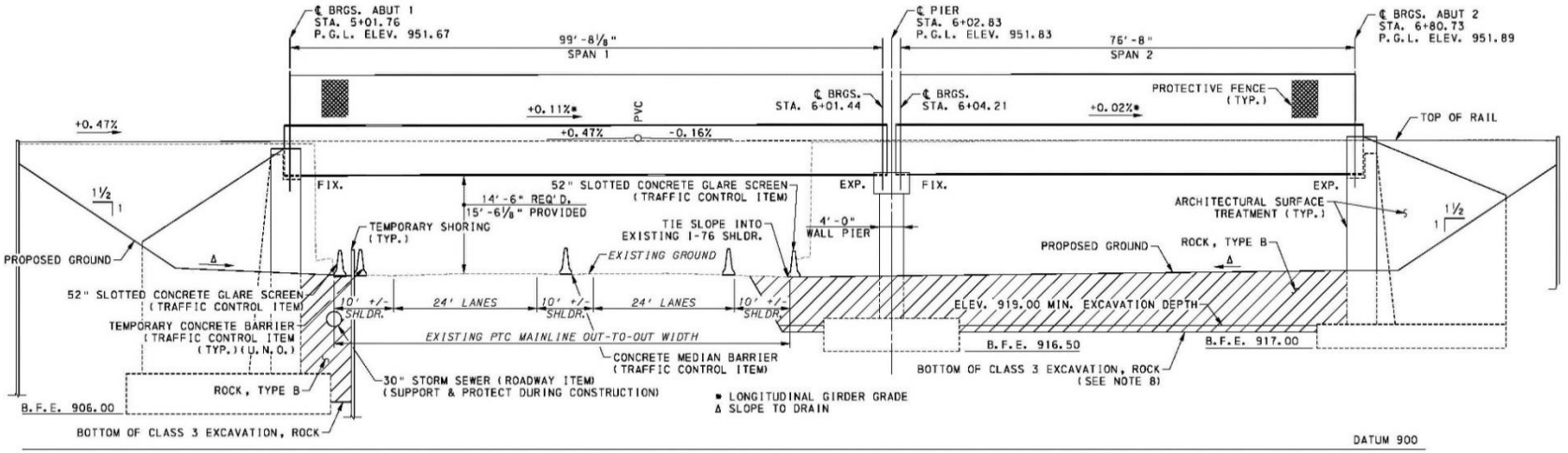
WB-207 & WB-208 Bridge Replacement Project



WB-208 Elevation

DESIGN

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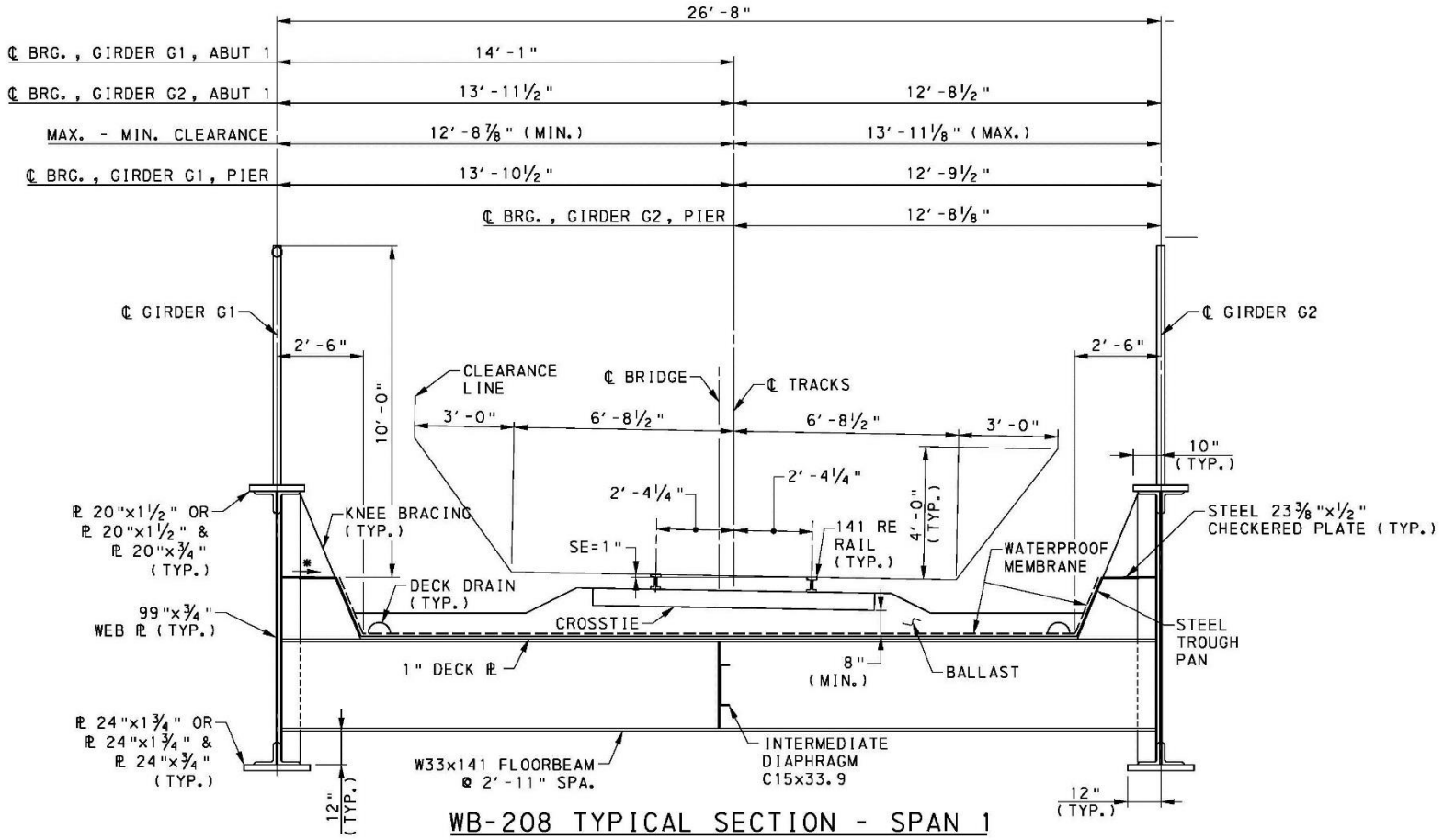
WB-207 & WB-208 Bridge Replacement Project

WB-208 Span 1 Typical Section (Span 2 Similar)



WB-208 TYPICAL SECTION - SPAN 1

DESIGN

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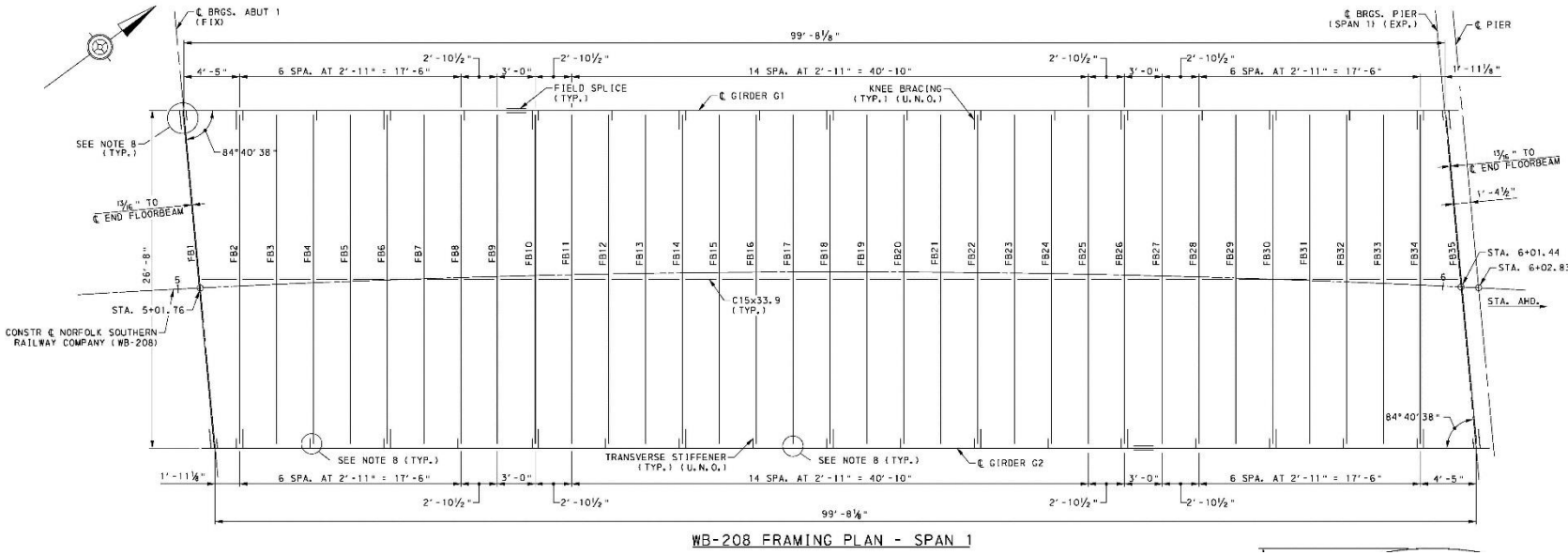
WB-207 & WB-208 Bridge Replacement Project

WB-208 Span 1 Framing Plan



WB-208 FRAMING PLAN - SPAN 1

DESIGN

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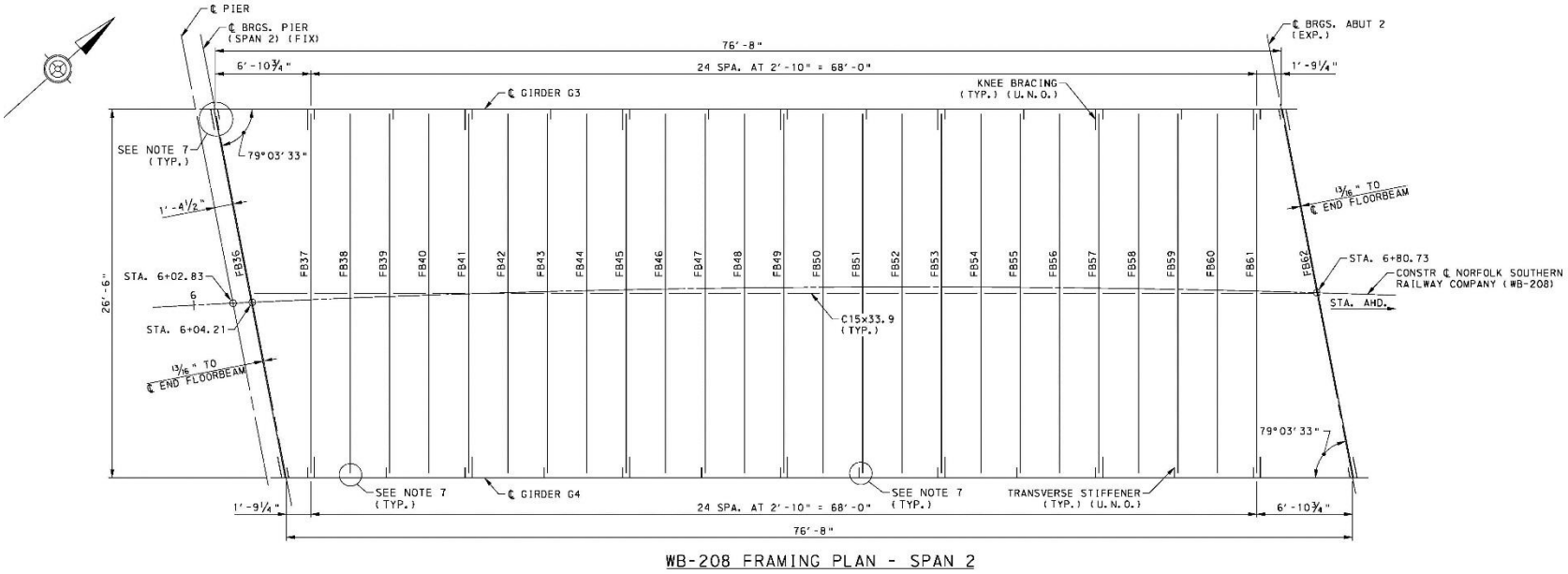
WB-207 & WB-208 Bridge Replacement Project

WB-208 Span 2 Framing Plan



WB-208 FRAMING PLAN - SPAN 2

DESIGN

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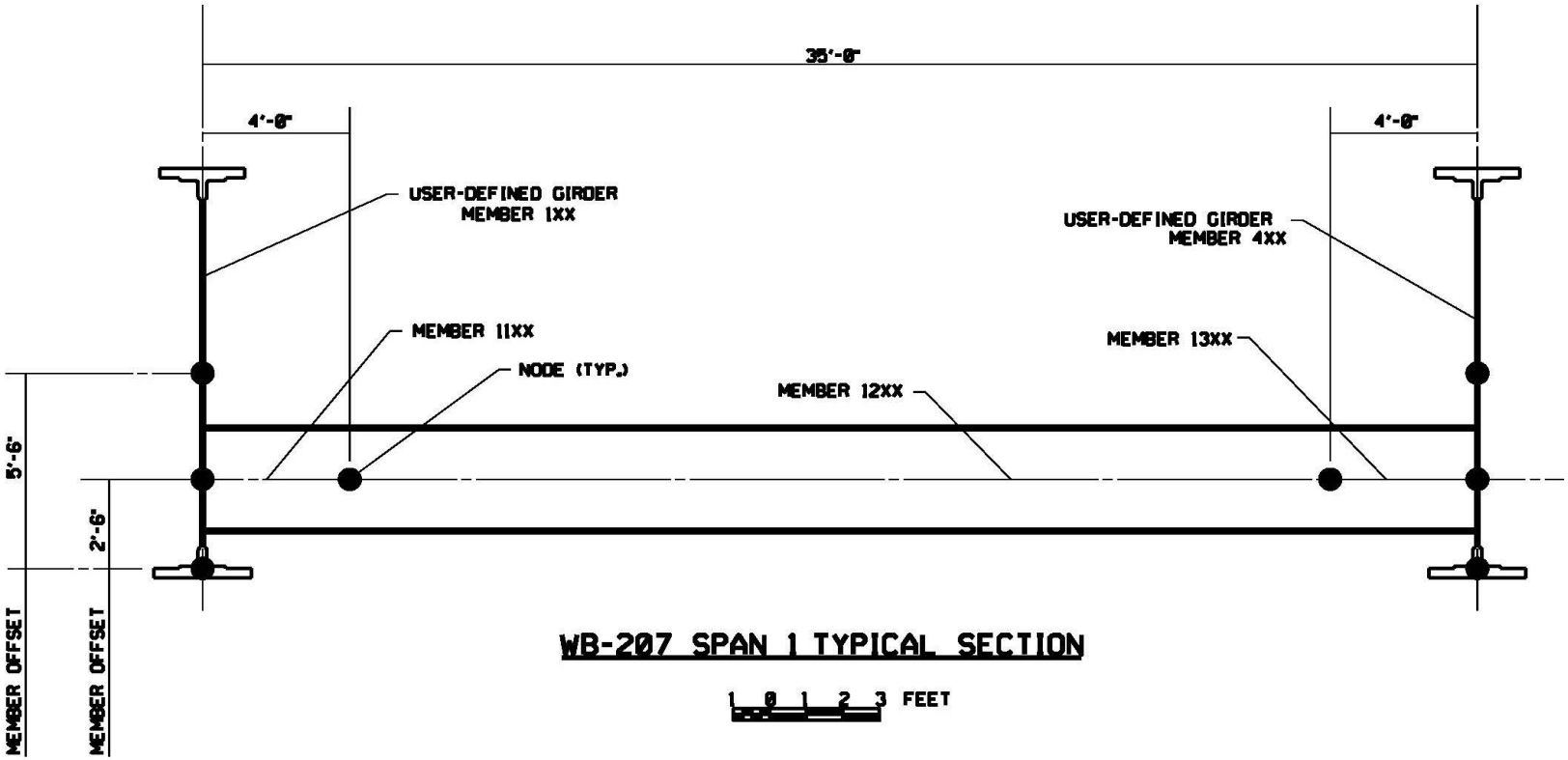
WB-207 & WB-208 Bridge Replacement Project

Because of the skew and track curvature, STAAD was used to model the superstructure



General STAAD Model Typical Section

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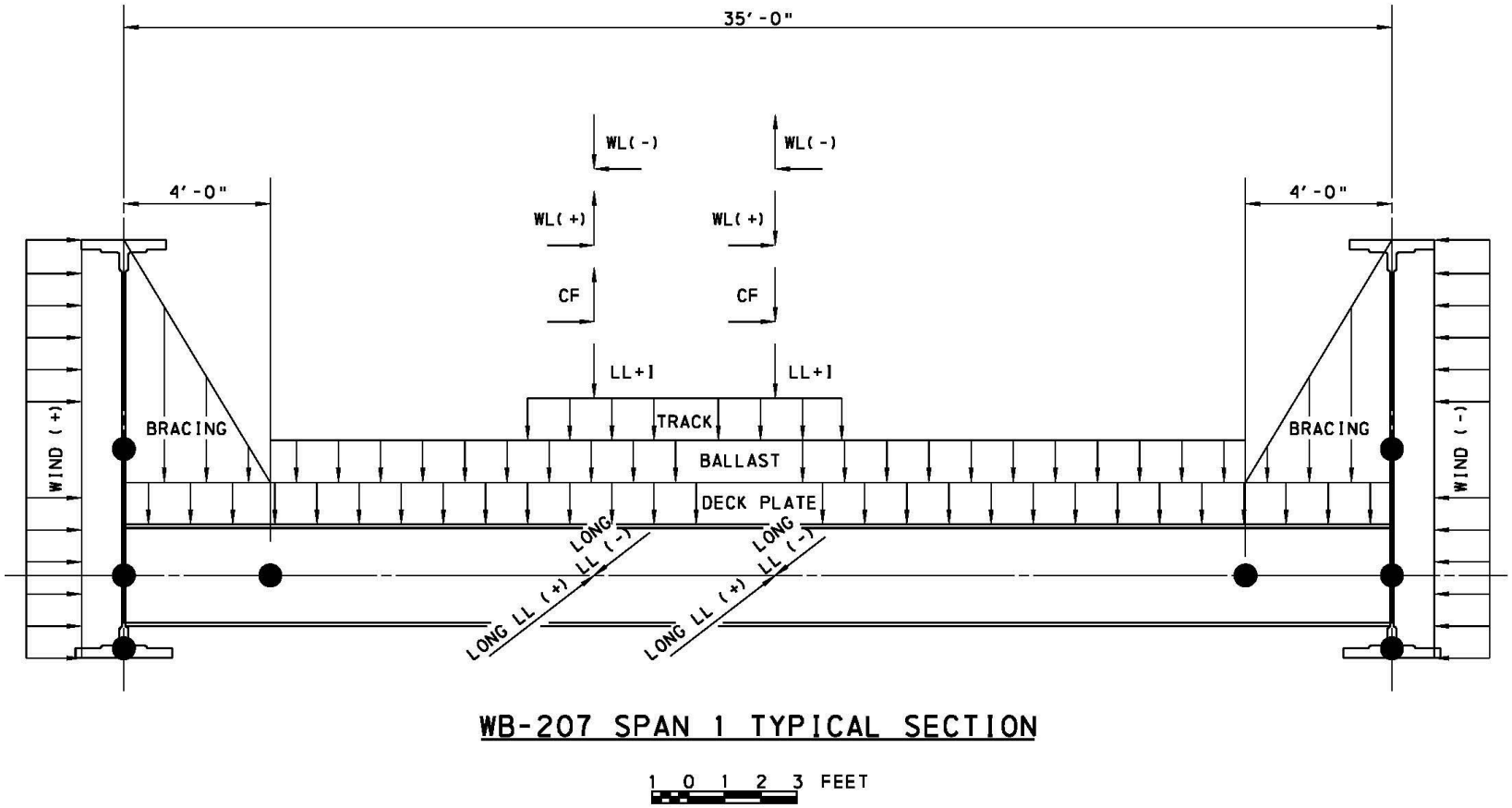
WB-207 & WB-208 Bridge Replacement Project

The STAAD model was created and loads were applied



STAAD Model Typical Section Loading

DESIGN

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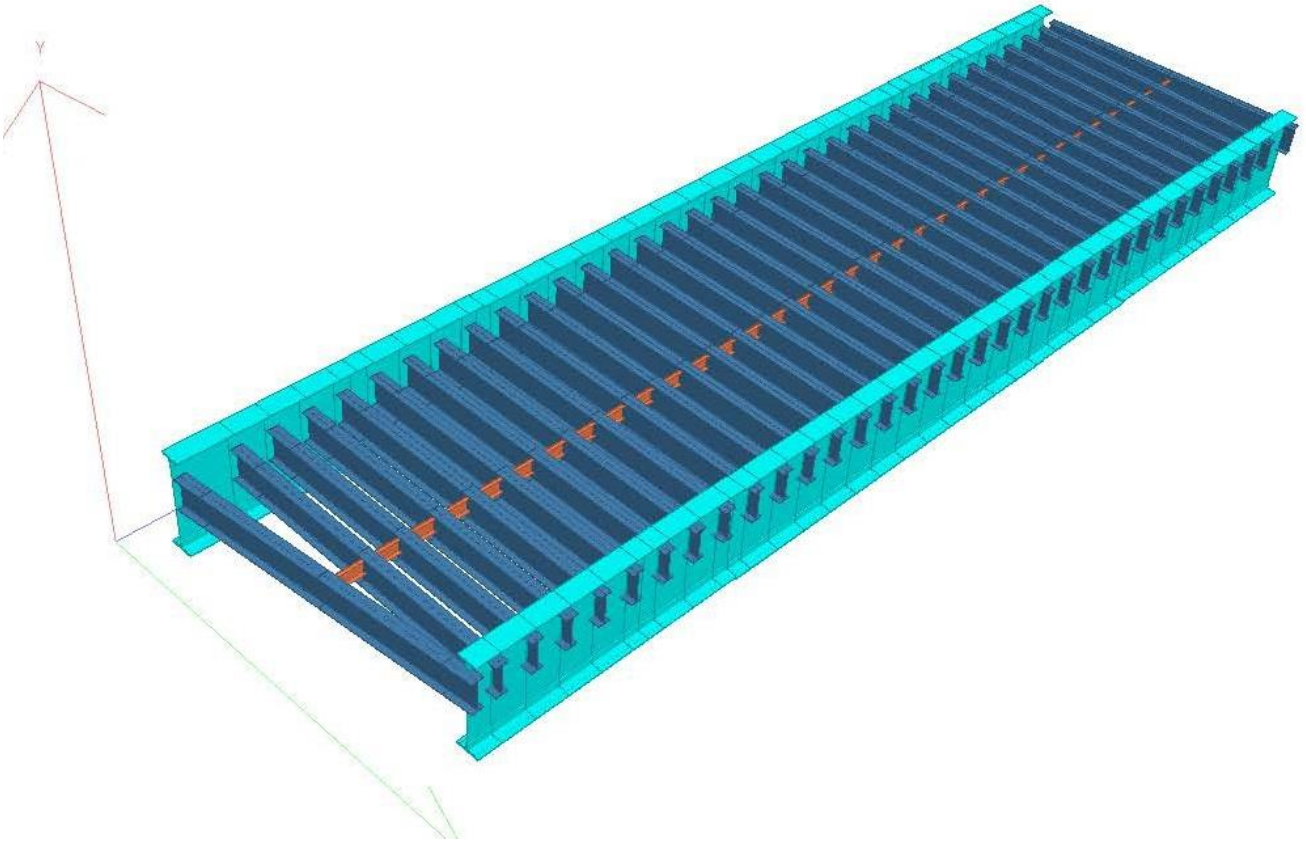
WB-207 & WB-208 Bridge Replacement Project

Because of the skew and track curvature, STAAD was used to model the superstructure



STAAD Model 3D Rendering

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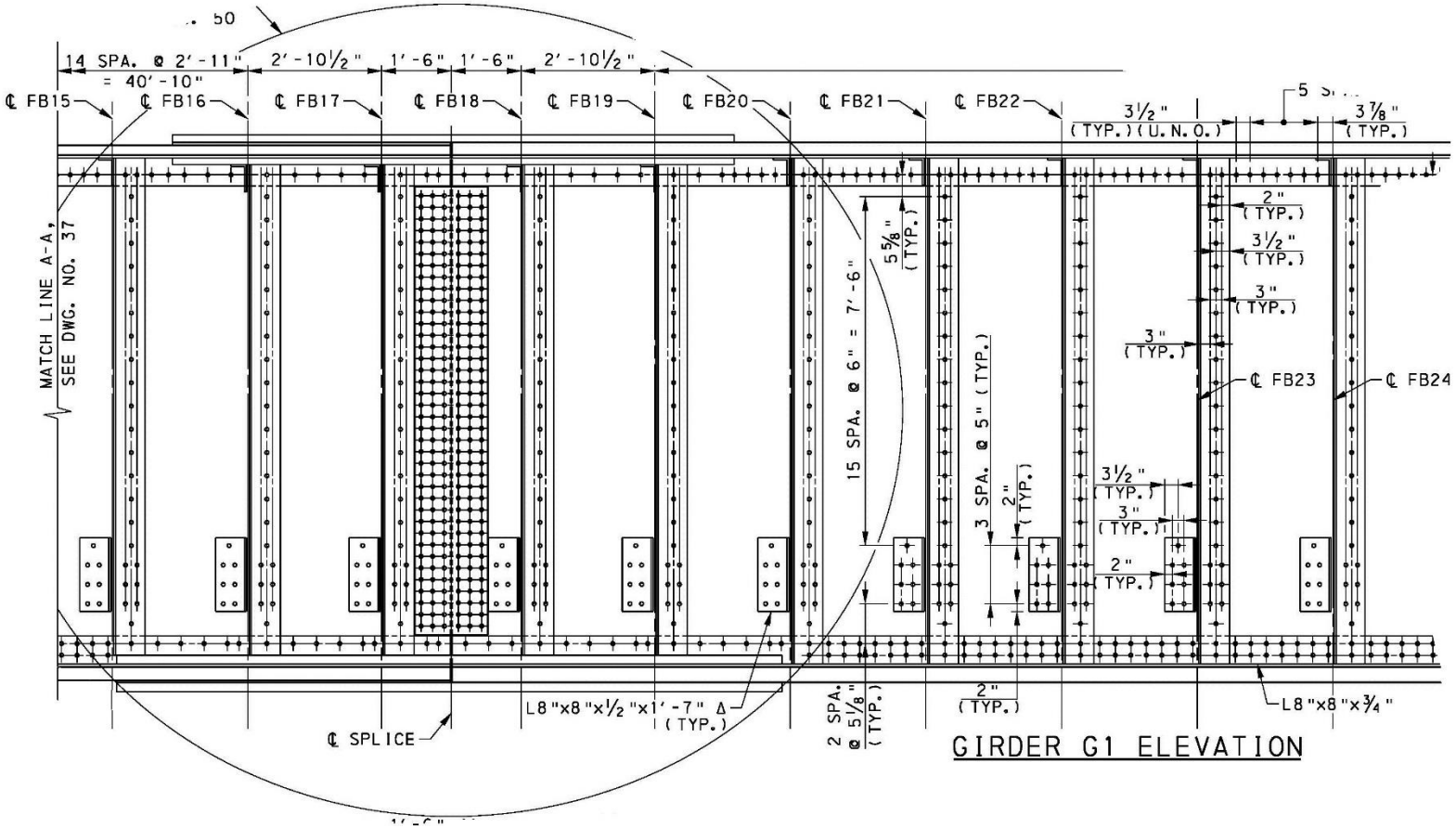
WB-207 & WB-208 Bridge Replacement Project



WB-207 Girder Elevation:

- **All bolted connections**
- **Detailed girder, floorbeam, & splice layout**
- **Complicated geometry**

DESIGN

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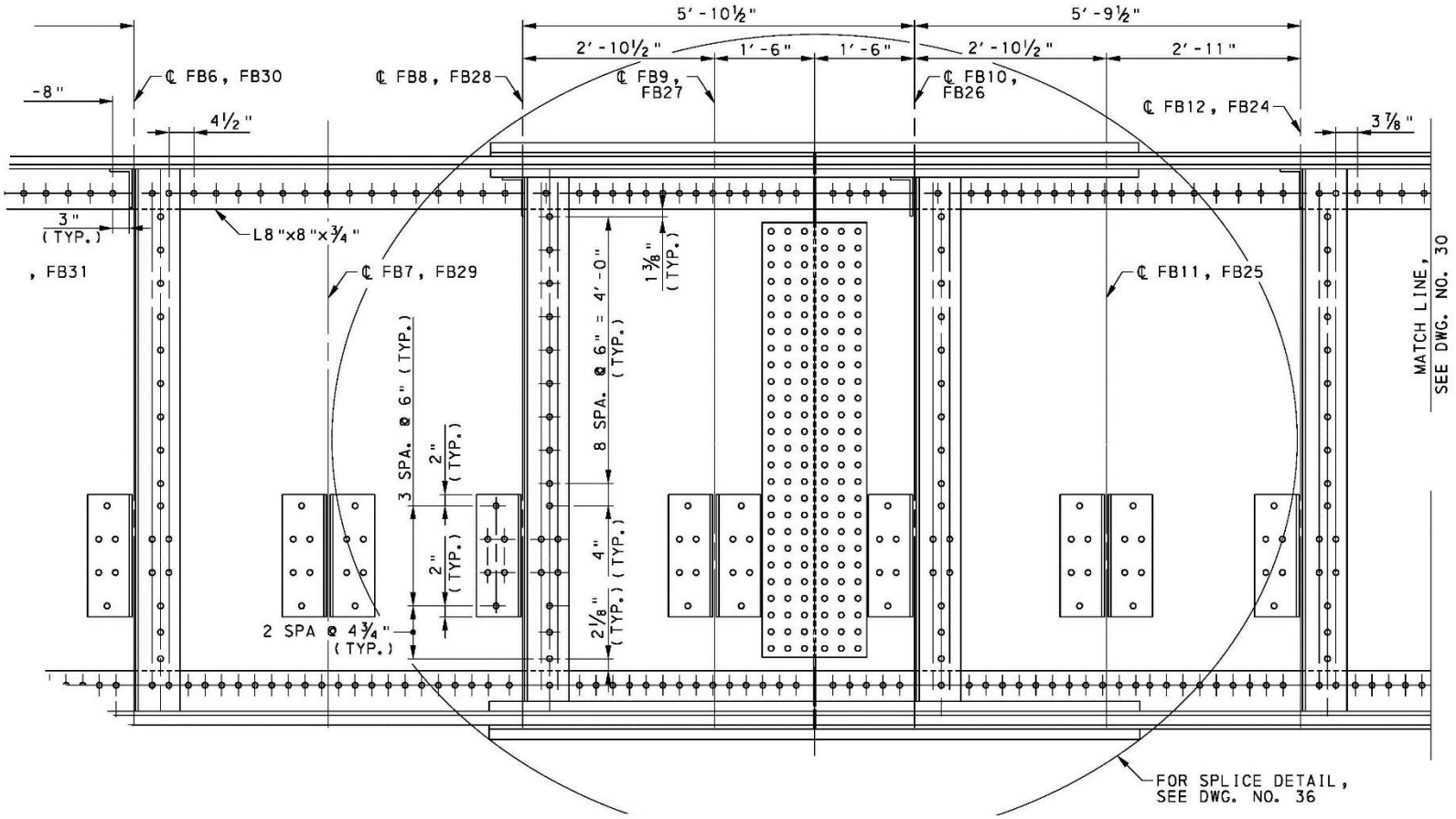
WB-207 & WB-208 Bridge Replacement Project



WB-208 Girder Elevation:

- **All bolted connections**
- **Detailed girder, floorbeam, & splice layout**
- **Fewer Knee Braces & Trans. Stiffeners Required**

DESIGN

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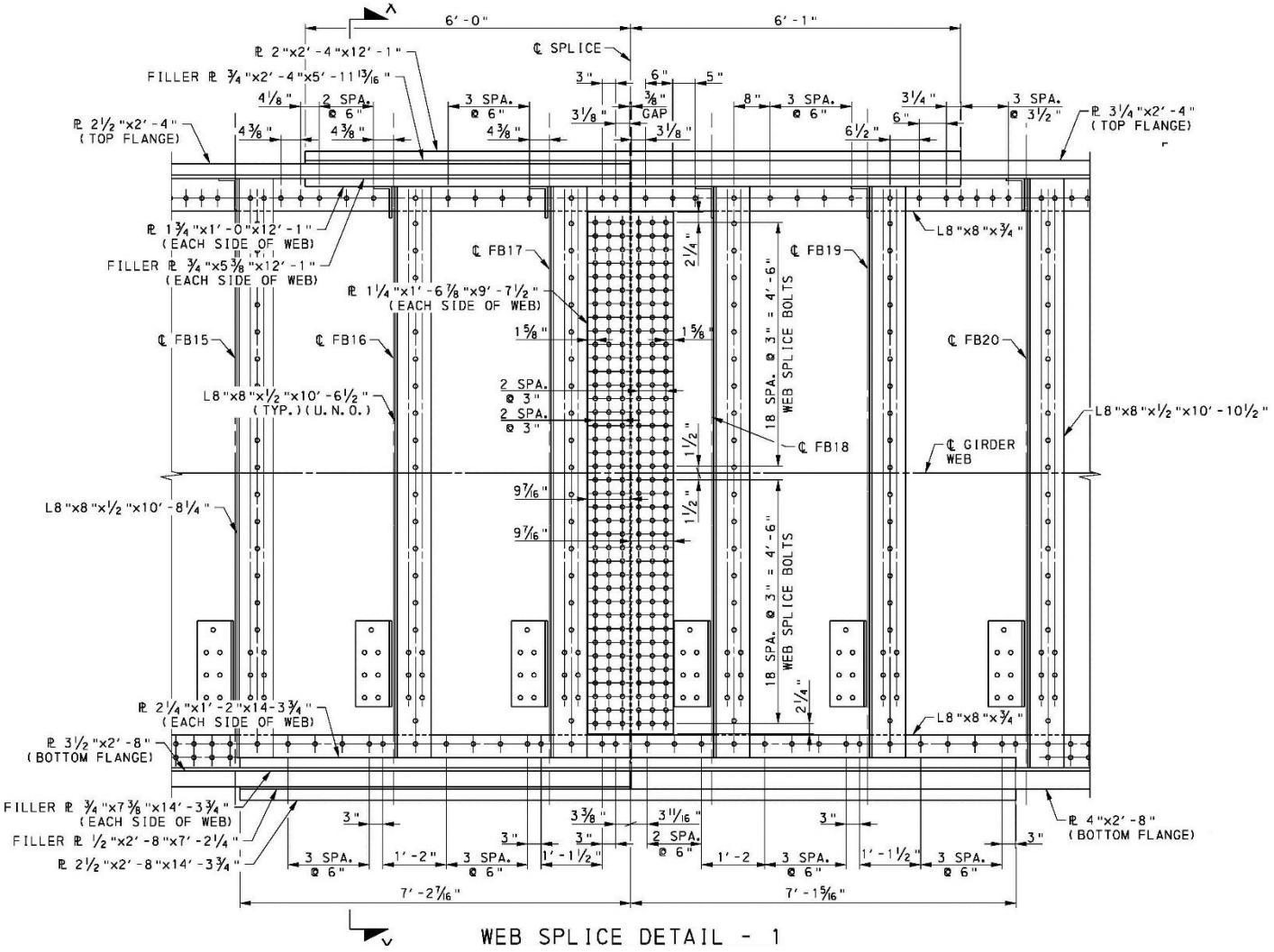
WB-207 & WB-208 Bridge Replacement Project



WEB SPLICE DETAIL - 1

DESIGN

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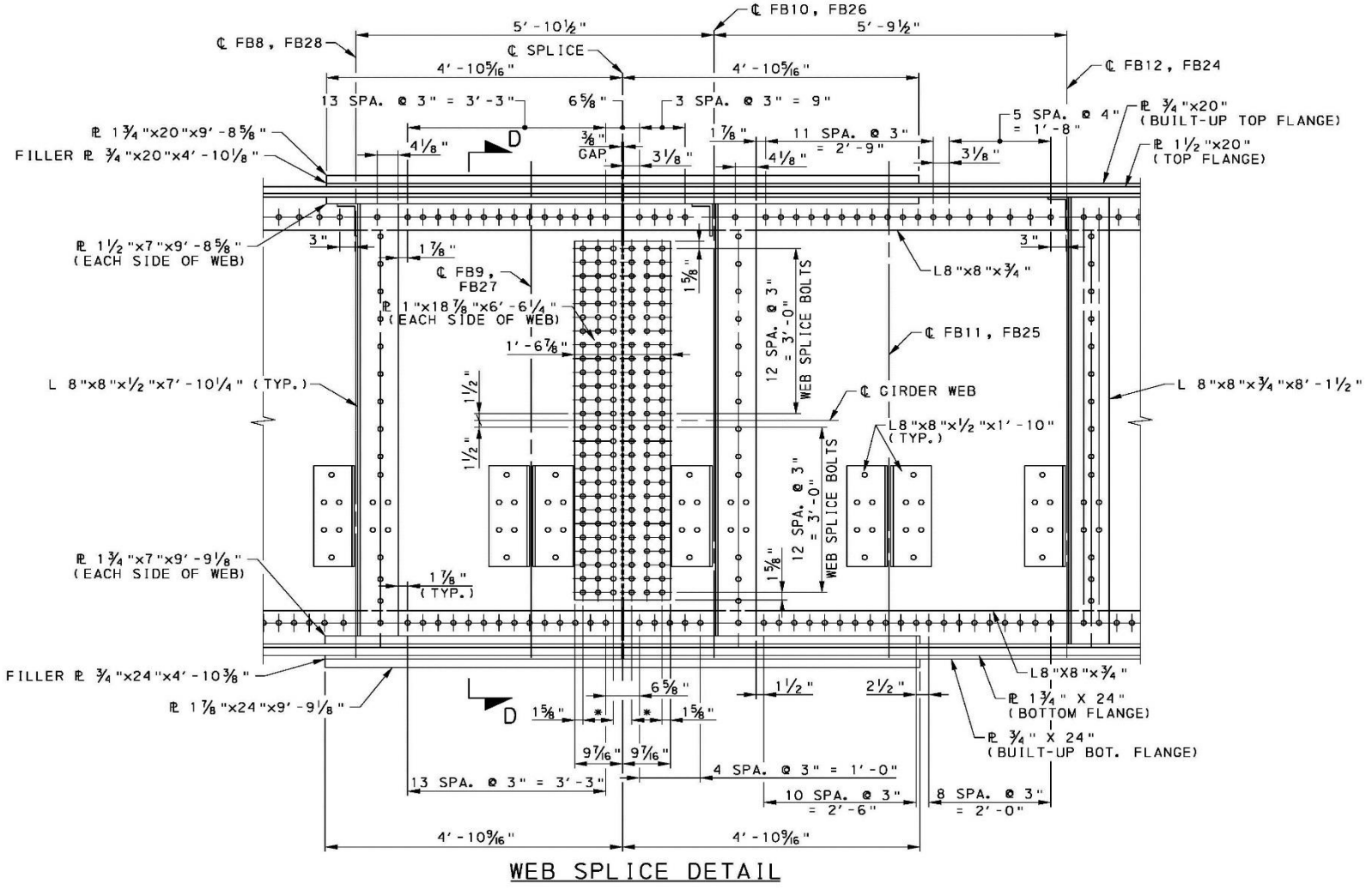
WB-207 Span 1 Splice

WB-207 & WB-208 Bridge Replacement Project



WEB SPLICE DETAIL

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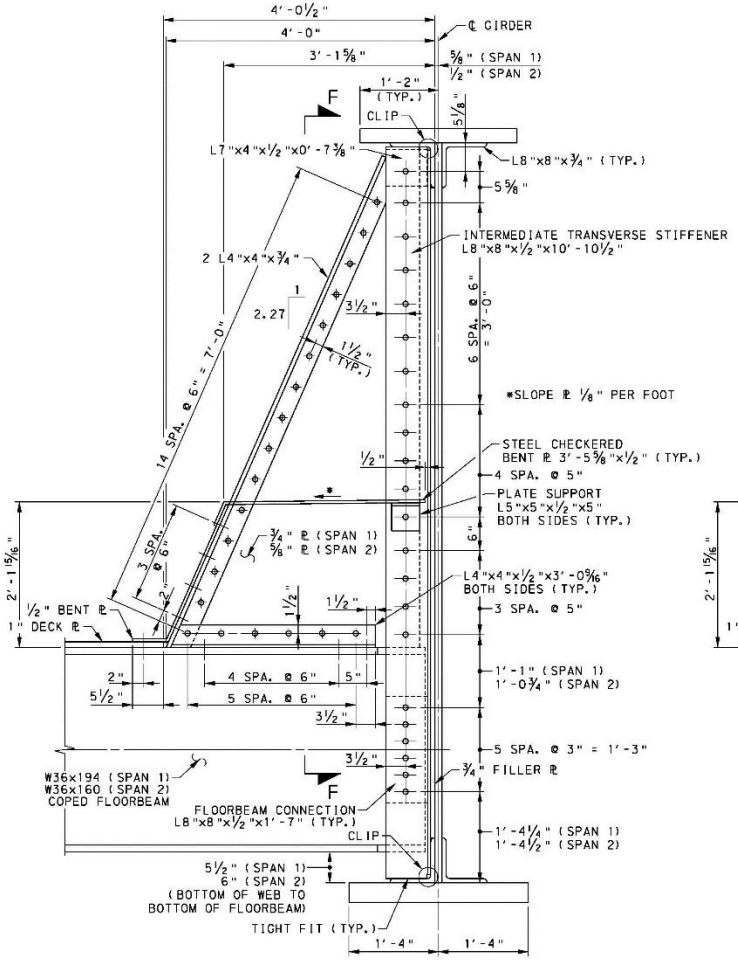
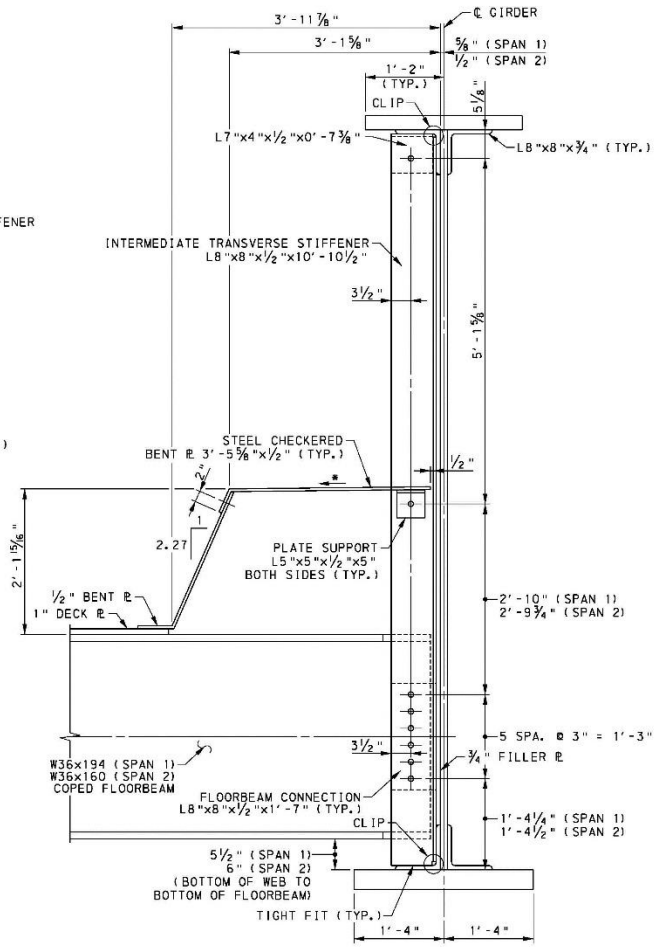
WB-208 Span 1 Splice

WB-207 & WB-208 Bridge Replacement Project



WB-207 SPAN 1 & SPAN 2
INTERMEDIATE FLOORBEAM
TYPICAL SECTION AT KNEE BRACE



WB-207 SPAN 1 & SPAN 2
INTERMEDIATE FLOORBEAM
TYPICAL SECTION AT INTERMEDIATE
TRANSVERSE STIFFENER

DESIGN

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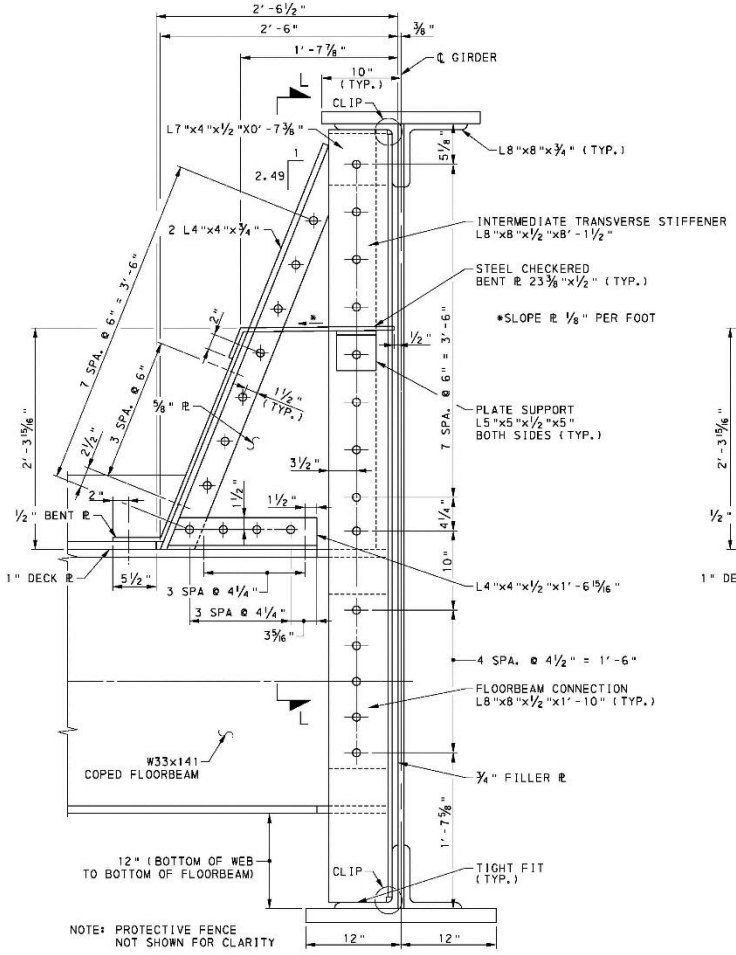
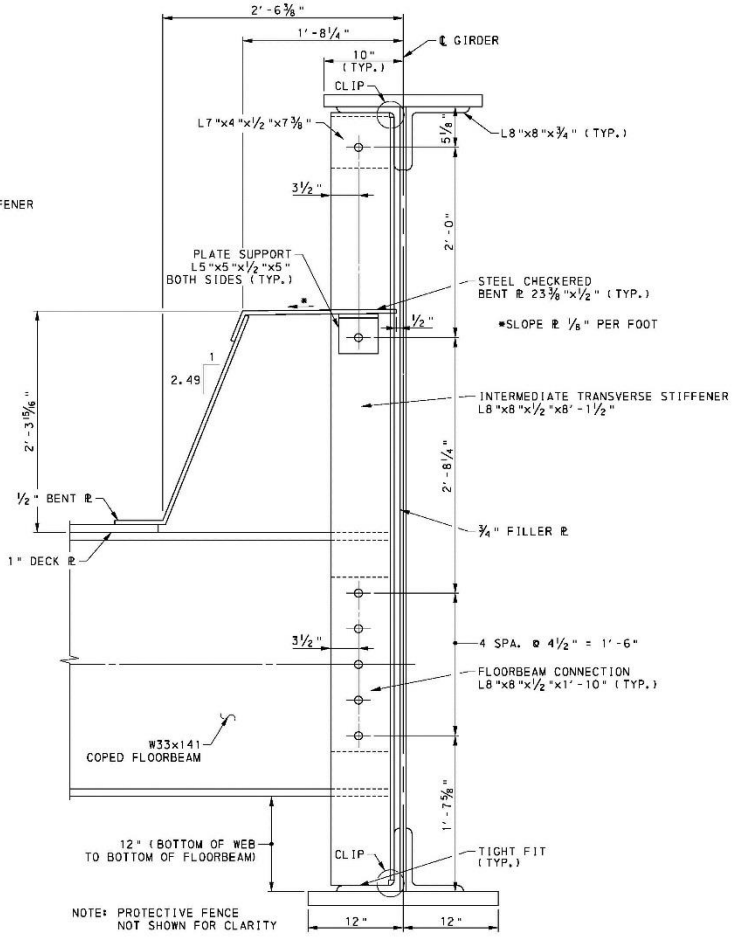
WB-207 Typical Knee Bracing & Trans. Stiffeners

WB-207 & WB-208 Bridge Replacement Project



WB-208 SPAN 1 & SPAN 2
INTERMEDIATE FLOORBEAM
TYPICAL SECTION AT KNEE BRACE



WB-208 SPAN 1 & SPAN 2
INTERMEDIATE FLOORBEAM
TYPICAL SECTION AT INTERMEDIATE
TRANSVERSE STIFFENER

DESIGN

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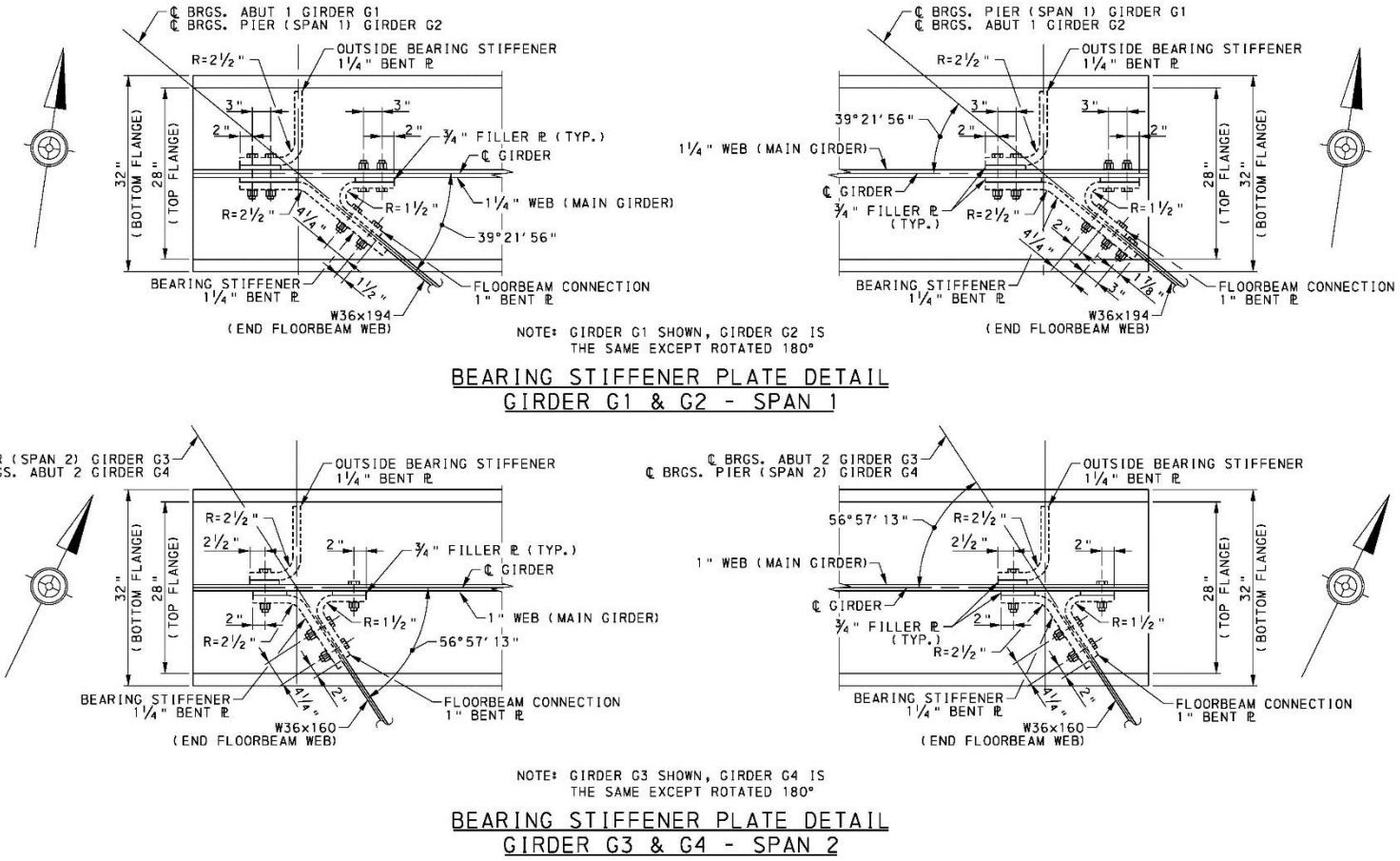
WB-208 Typical Knee Bracing & Trans. Stiffeners

WB-207 & WB-208 Bridge Replacement Project



DESIGN

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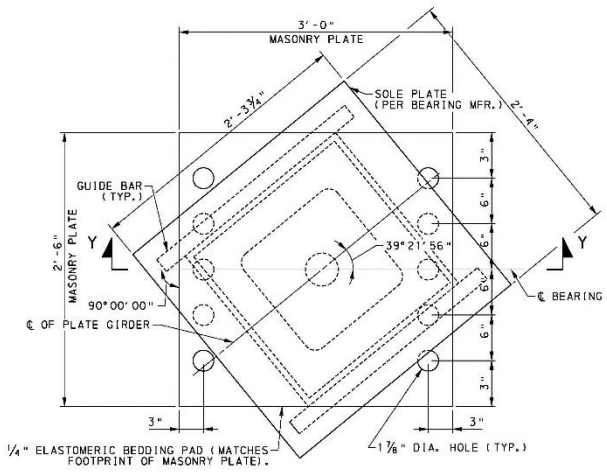
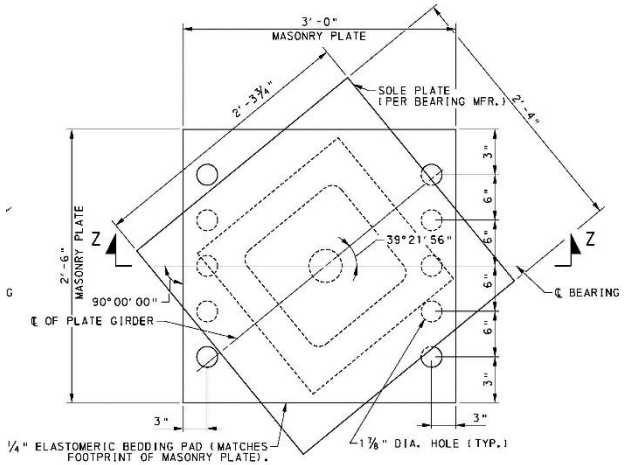
WB-207 Bearing Stiffeners & End Floorbeam Connections

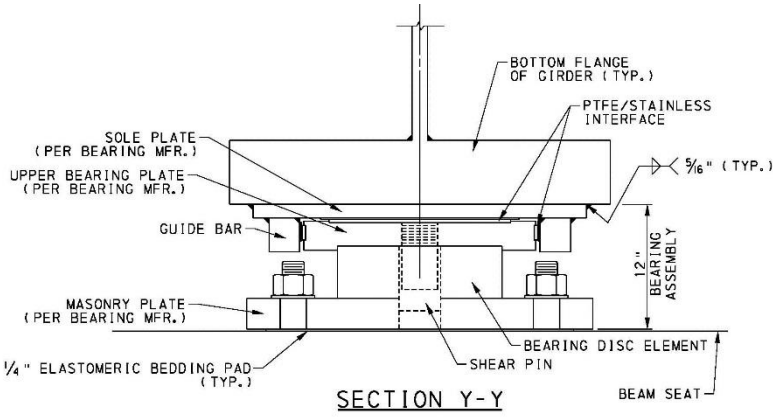
WB-207 & WB-208 Bridge Replacement Project



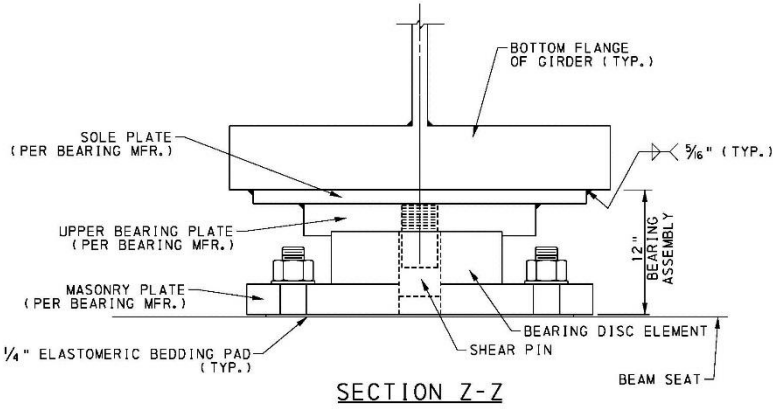
EXPANSION BEARING DETAIL
SPAN 1 - ABUT. 1



FIXED BEARING DETAIL
SPAN 1 - PIER



SECTION Y-Y



SECTION Z-Z

- **Disc bearings used**
- **Bolt clearance an issue due to sharp skew**

DESIGN

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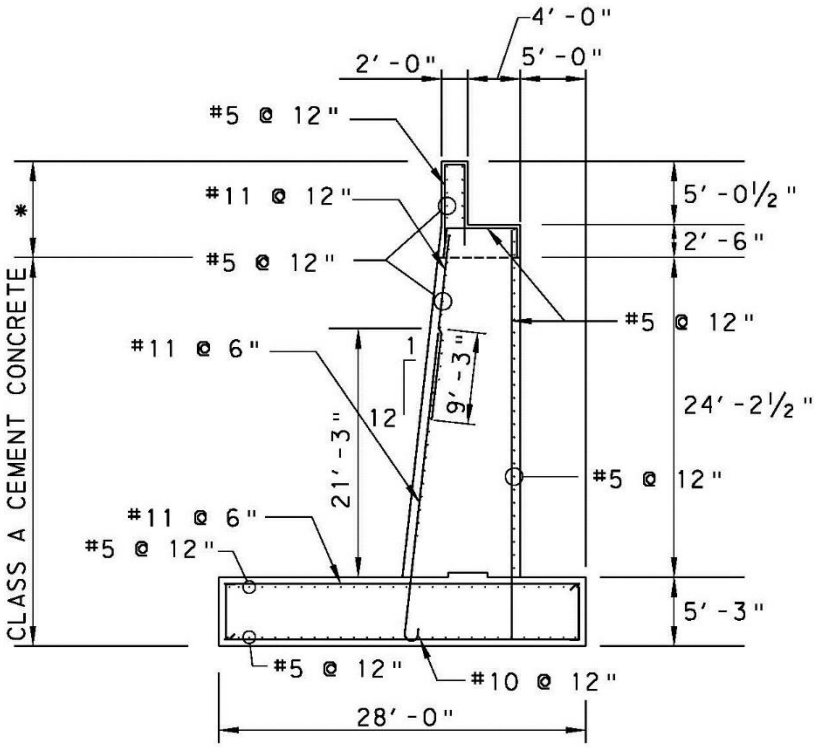
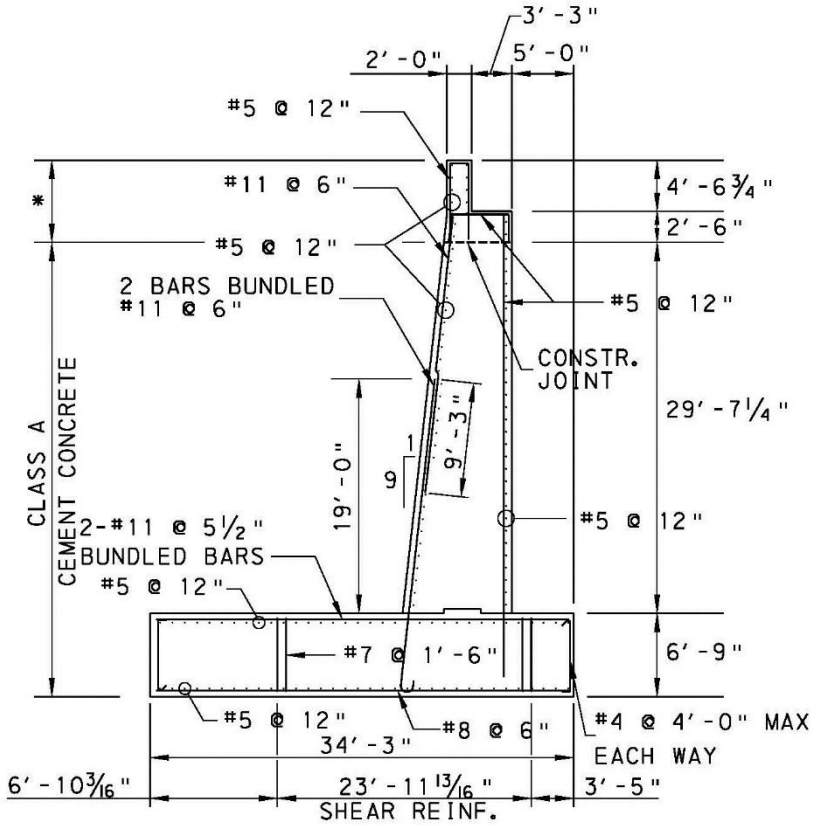
WB-207 & WB-208 Bridge Replacement Project

Location of EB deceleration ramp required the design of tall abutments



WB-207 Abut. 1
Expansion



WB-208 Abut. 1
Fixed

DESIGN

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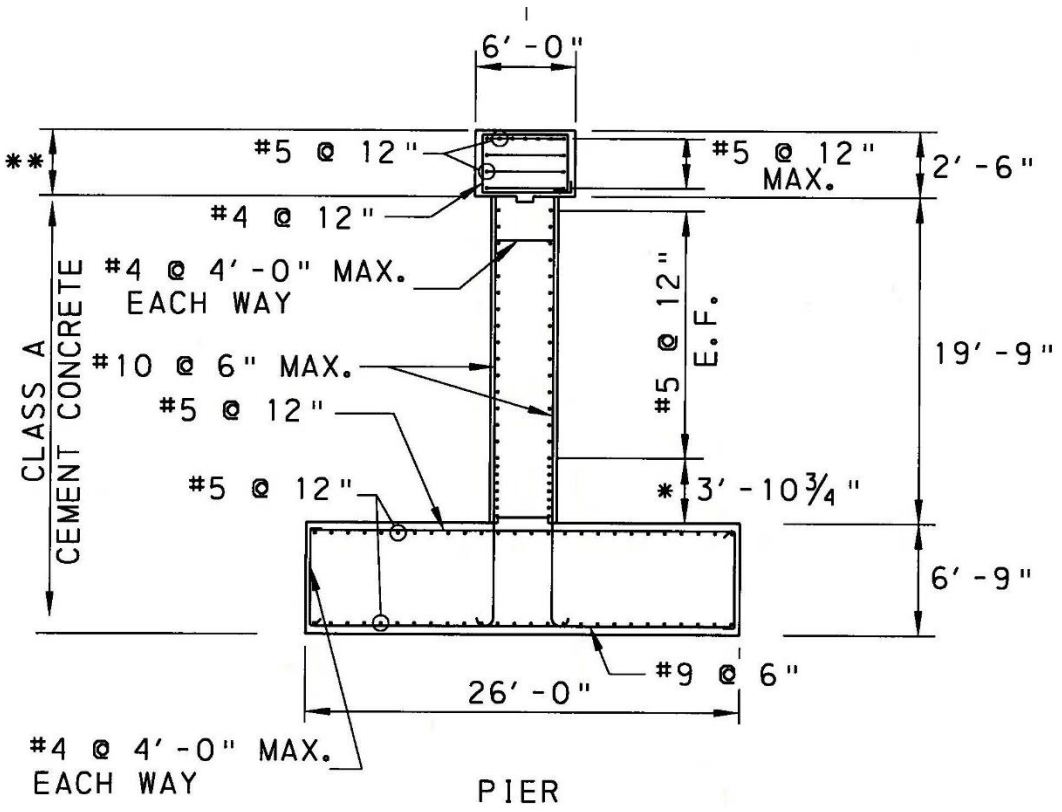
WB-207 & WB-208 Bridge Replacement Project

Skew and bearing fixity resulted in large pier caps and footings



WB-207 Pier Fix./Exp.

WB-208 Pier Exp./Fix.

DESIGN

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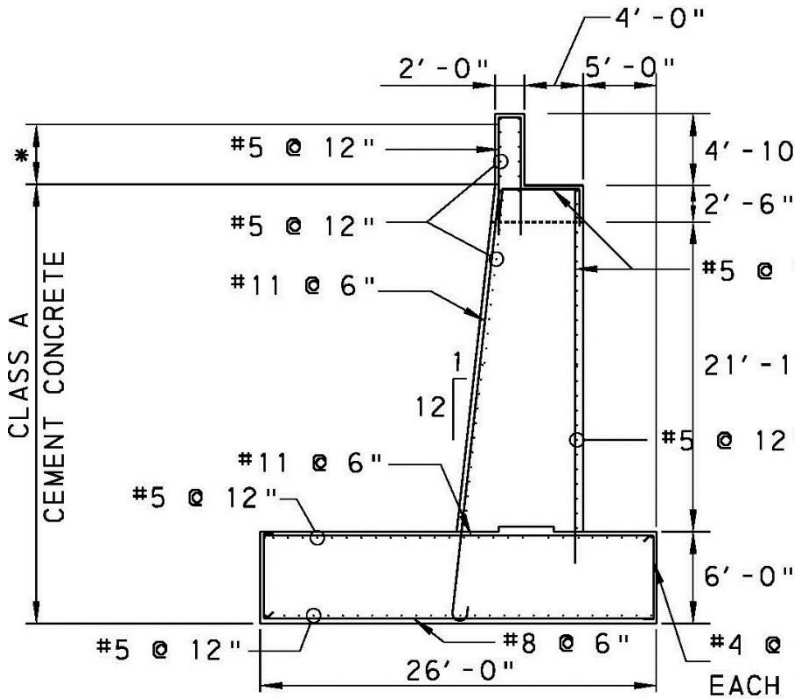
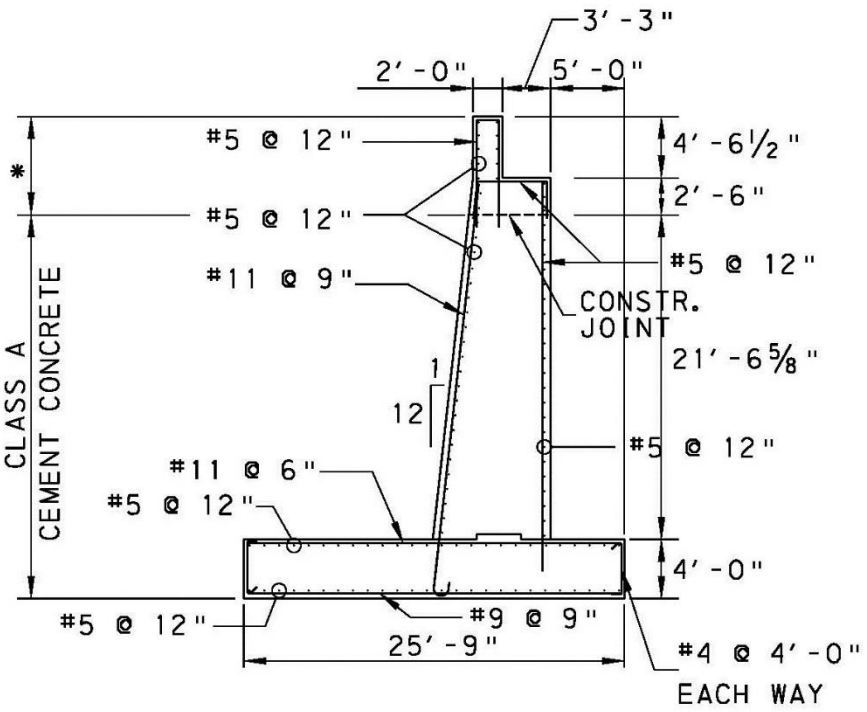
WB-207 & WB-208 Bridge Replacement Project

The location of the Span 2 girders necessitated the use of a common north abutment



WB-208 Abut. 2
Fixed



WB-208 Abut. 2
Expansion

DESIGN

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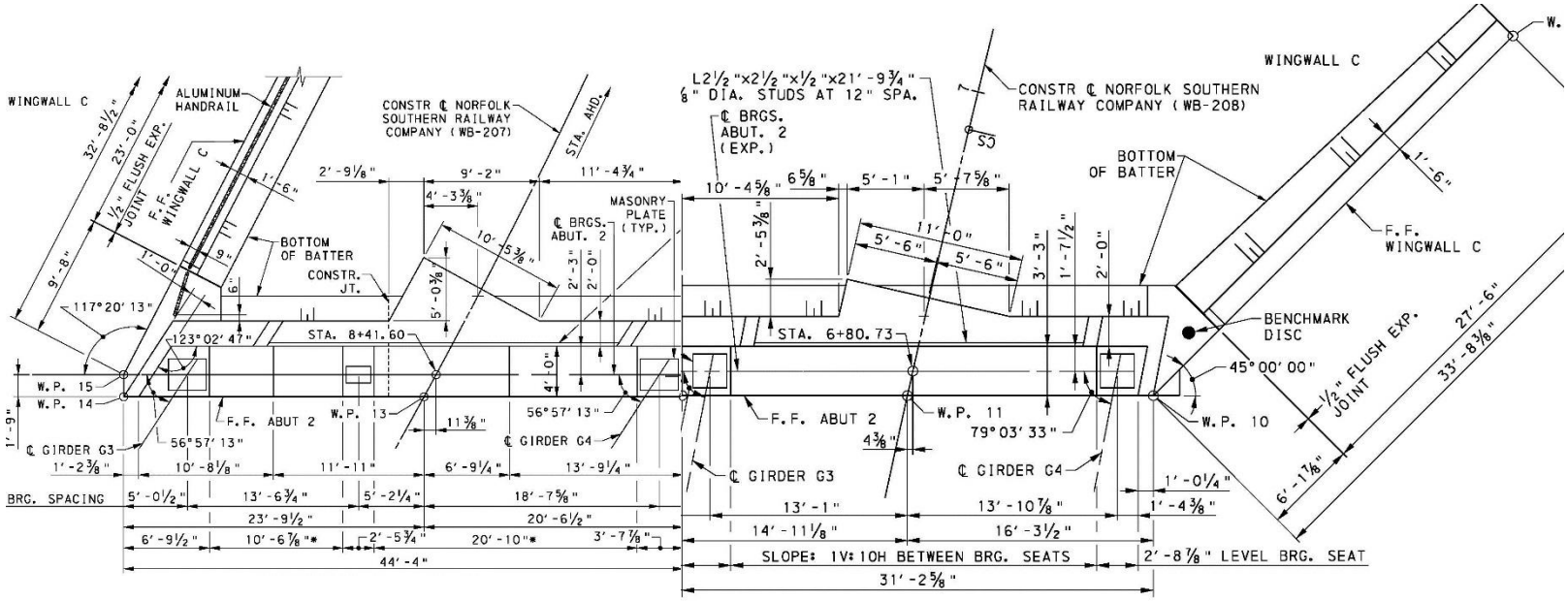
WB-207 & WB-208 Bridge Replacement Project

The location of the Span 2 girders necessitated the use of a common north abutment



WB-208 Abut. 2 Fixed

WB-208 Abut. 2 Expansion

DESIGN

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Fabrication & Constructability

WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up

Typical Section Showing:

- Girders
- Knee bracing & trans. stiff.
- Deck plate
- Ballast retainer plates

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WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up

Skew at WB-207 Span 1

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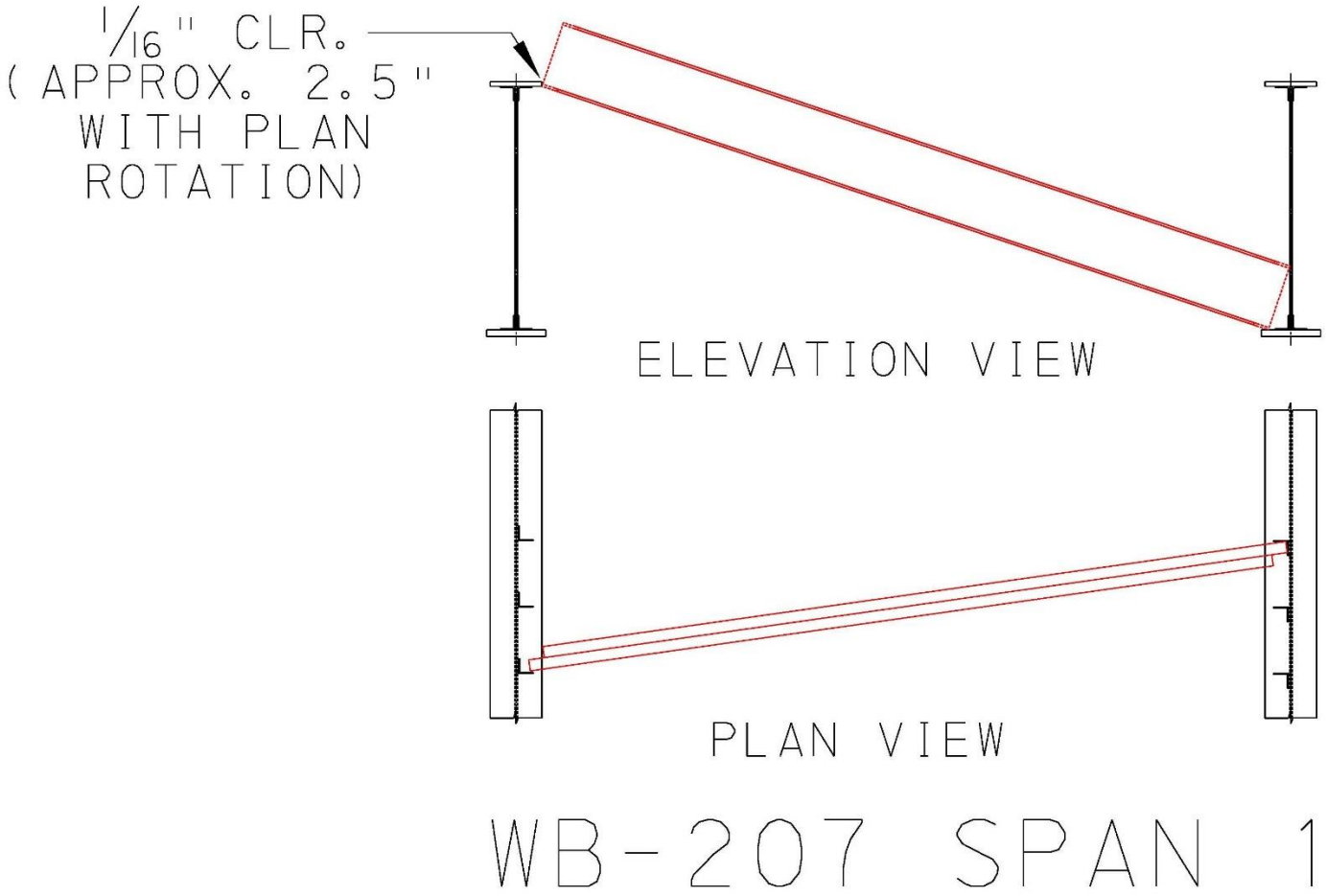
WB-207 & WB-208 Bridge Replacement Project

Constructability



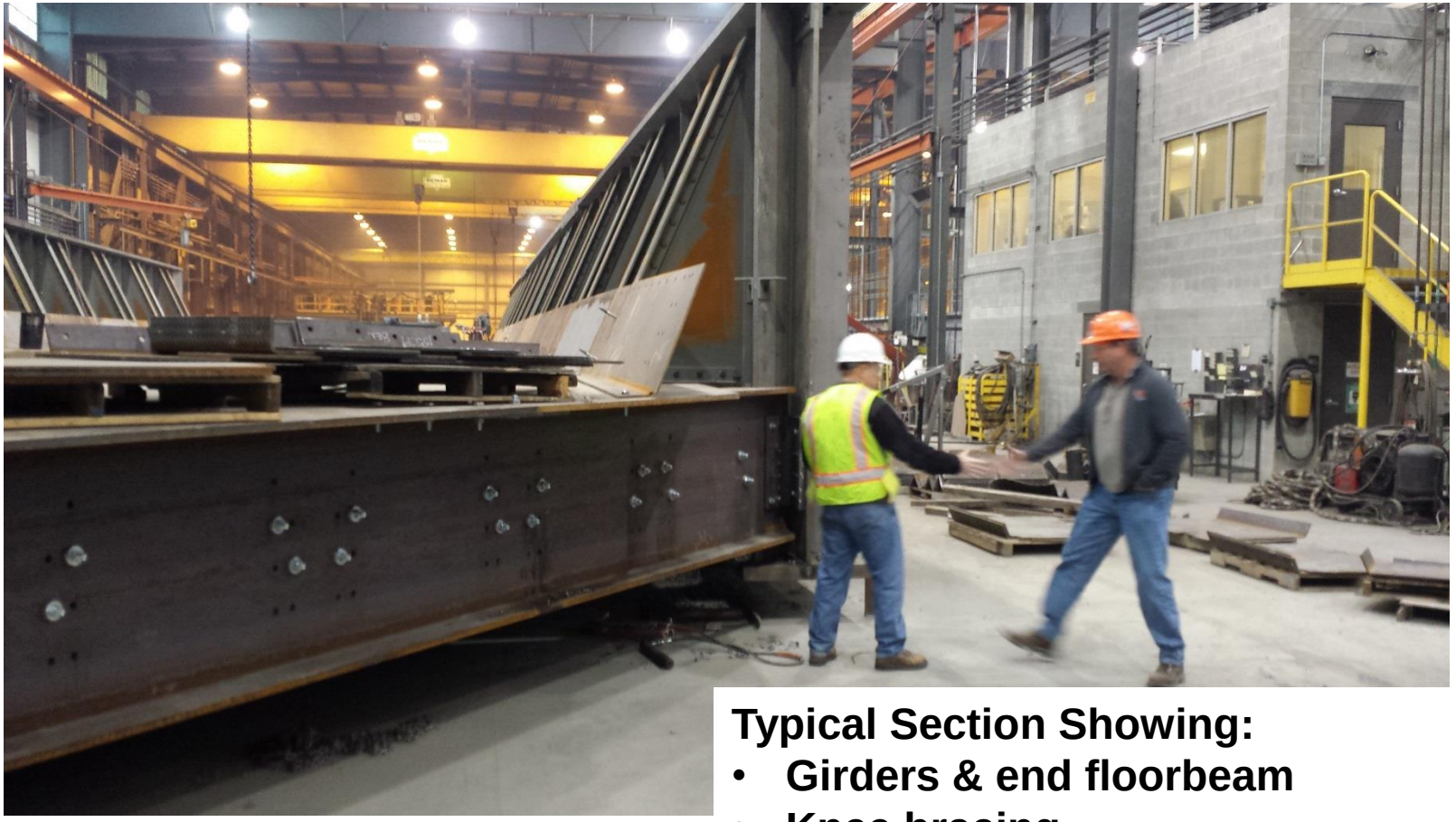
FABRICATION

CDR MAGUIRE

WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up



Typical Section Showing:

- Girders & end floorbeam
- Knee bracing
- Bearing stiffeners
- Ballast retainer plates

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WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up

End floorbeam connection

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WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up

Knee bracing

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FABRICATION

Shop Fit-Up

Checker plate walking surface

FABRICATION

Shop Fit-Up

Deck plate

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WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up

WB-207 Span 1 Field Splice

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FABRICATION

Shop Fit-Up

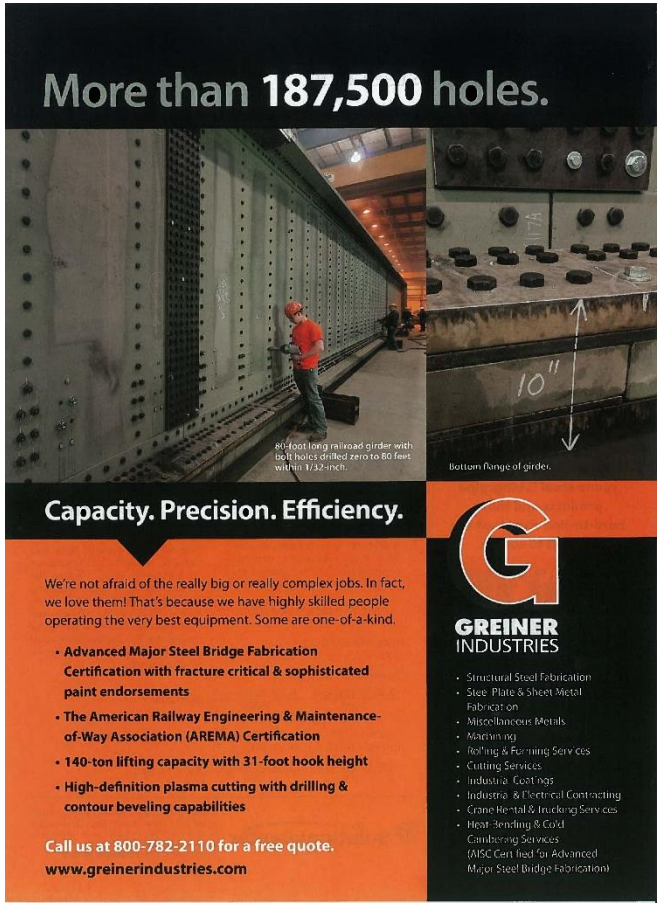
WB-207 Span 1 Field Splice

CDR MAGUIRE

WB-207 & WB-208 Bridge Replacement Project

FABRICATION

Shop Fit-Up



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All bolted connections

Construction

WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION CRITERIA

Norfolk Southern Construction Requirements:

- **Wye acts as emergency detour of the Fort Wayne Line (Pittsburgh to Chicago)**
- **Cannot close both legs of Wye simultaneously**
- **West leg of Wye must remain in operation at all times**
- **Outage of the east leg of the Wye permitted for 22 months**
- **New WB-207 and WB-208 bridges will be constructed during the 22 month outage of the east leg of the Wye**
- **NS will remove existing rails and ties**
- **Contractor will install deck ballast and approach track subballast**
- **After new bridges are in service, Contractor will demo the existing WB-207 bridge**
- **Contract used preapproved temporary at-grade crossing locations**

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION CRITERIA

As-Designed Quantities:

- **62,668 CY Class 3 Excavation, Rock**
- **5,195 CY Class A & AA Cement Concrete**
- **9,431 CY Selected Borrow Excavation, Structure Backfill**
- **495,645 lbs. Reinforcement Bars, Epoxy Coated**
- **2,506,300 lbs. Fabricated Structural Steel**
- **22 High Load Disc Bearings**

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION CRITERIA

Bids:

- **June 12, 2013 Let Date**
- **$12,987,728.85 low bid**
- **$13,620.613.69 2nd low bid**
- **$632,884.84 or 5% left on the table**
- **Mosites Construction Company of Pittsburgh, PA was low bidder**
- **NTP issued on July 30, 2013**
- **Required completion date is November 15, 2015**

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Begin Excavation

- No blasting
- Shore along WB-207 bridge and PTC mainline
- Begin hoe ramming

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Temporary Shoring Along Existing WB-207 Bridge

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CONSTRUCTION

Excavation

WB-207 Abut. 1

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Abut. 1 Construction

- Abutment footing poured
- Tying abutment stem rebar
- Forming stem

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Abut. 1 Construction

- Abutment footing poured
- Forming abutment stem
- Wingwall footing rebar in place
- Tying RF wingwall rebar

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Abut. 1 Complete

- Form liner
- Approach slab
- Stepped wingwall footing

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CONSTRUCTION

Architectural Surface Treatment

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Pier & Abut. 2 Construction

- WB-207 tracks supported
- Pier footings poured
- Pier stem & abutment footing rebar tied

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

View Showing Piers & Southern Abutments

- Existing WB-207 bridge
- PP 12.58 EB retaining wall
- WB-207 Abut. 1 complete
- WB-208 Abut. 1 form stripping

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Substructures Complete

- All substructures completed
- Structure backfill in place

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 2 Girder Erection

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 2 Floorbeam Erection

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 2 Girder Erection

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 2 Showing Floorbeams

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-208 Span 2 Girder Erection

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 1 Erection

- Plan X closure during erection
- Partial erection of girders using temporary towers
- Short term single lane closure needed for crane

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 1 Erection

- Temporary towers
- Short term single lane closure

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 1 Floorbeam Erection

- Erection of remaining Span 1 floorbeam and girder length
- Performed under live traffic but with one lane closed

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

WB-207 Span 1 Girder Erection

- Crew installing field splice bolts
- Crane used: Manitowoc 2250

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Erection of Final WB-207 Span 1 Girder Piece

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WB-207 & WB-208 Bridge Replacement Project

Erection of WB-207 Span 1 Floorbeams

CONSTRUCTION

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Erection Complete

- Erection started: Dec. 2014
- Erection completed: April 2015
- Ballast installed by Contractor
- Ties and rails installed by NS

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Aerial Photos

Overhead view

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Aerial Photos – Looking West

WB-208 in foreground

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WB-207 & WB-208 Bridge Replacement Project

CONSTRUCTION

Aerial Photos – Looking East

- Homewood Viaduct (near)
- WB-207 Bridge
- WB-208 Bridge
- Beaver Valley Interchange (far)

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WB-207 & WB-208 Bridge Replacement Project at M.P. 12.63 & 12.67 in Beaver County

Pennsylvania Turnpike Commission:

Brad Updegrave, P.E. – Project Manager
Jim Stump, P.E. – Bridge Engineer Manager
Gary Graham, P.E. – Assistant Chief Engineer – Design

Subconsultants:

AWK Consulting Engineers, Inc.
SP&K Engineering, Inc.
SAI Consulting Engineers, Inc.

Thank you!

WB-207 & WB-208 Bridge Replacement Project

Thank you!

CONSTRUCTION

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Questions?