Sauvie Island Bridge Arch Span

Multnomah County, Oregon

Presented by:

Ian Cannon, PE – Multnomah County
Eric Rau, PE – David Evans and Associates, Inc.

Project Team

- Owner and construction manager: Multnomah County
- Contracting agency: Oregon Department of Transportation
- Designer: David Evans and Associates, Inc.
- Architect: H2L2
- General contractor: Max J. Kuney Co.
- Steel fabricator: Fought & Co.
- Steel assembly sub: Schneider Up
- Load/transport/install sub: Dix/Norsar

Agenda

- Project background
- Replacement Bridge Design
- Steel Shop Fabrication
- Arch Assembly and Transportation
- Completed Construction
- Questions

Project Background

Presented by

Ian Cannon, Multnomah County

CONNECTING COMMERCE AND COMMUNITY

MULTNOMAH COUNTY

BRIDGES

Sauvie Island

- 24,000-acre island
- Bounded by the Columbia River, Willamette River and Multnomah Channel
- Existing bridge provides only vehicular access

Existing Sauvie Island Bridge

- Existing bridge constructed in 1950 and was the first bridge to the Island
- 14 spans, 1198' long
- Eligible for listing on National Register of Historic Places
- Carries local residential, agricultural, industrial and recreational traffic
- Vessel traffic in channel – pleasure craft to commercial vessels

Existing Sauvie Island Bridge

- After 50 years of life the existing bridges was functionally obsolete and structurally deficient
- David Evans and Associates (DEA) provided design services to Multnomah County
  - Completed an Alternative Study in 2002
  - DEA completed final design in 2005
- Contract awarded to Max J. Kuney Co. in 2005
  - Construction completed in 2008

Replacement Bridge

Presented by

Eric Rau, David Evans and Associates, Inc.

Replacement Bridge

- 5 spans, 1177’ long
- 365’ steel tied arch main span
- Concrete box girder approach spans
- Large-diameter drilled shaft foundations

Approach Spans and Substructure Construction

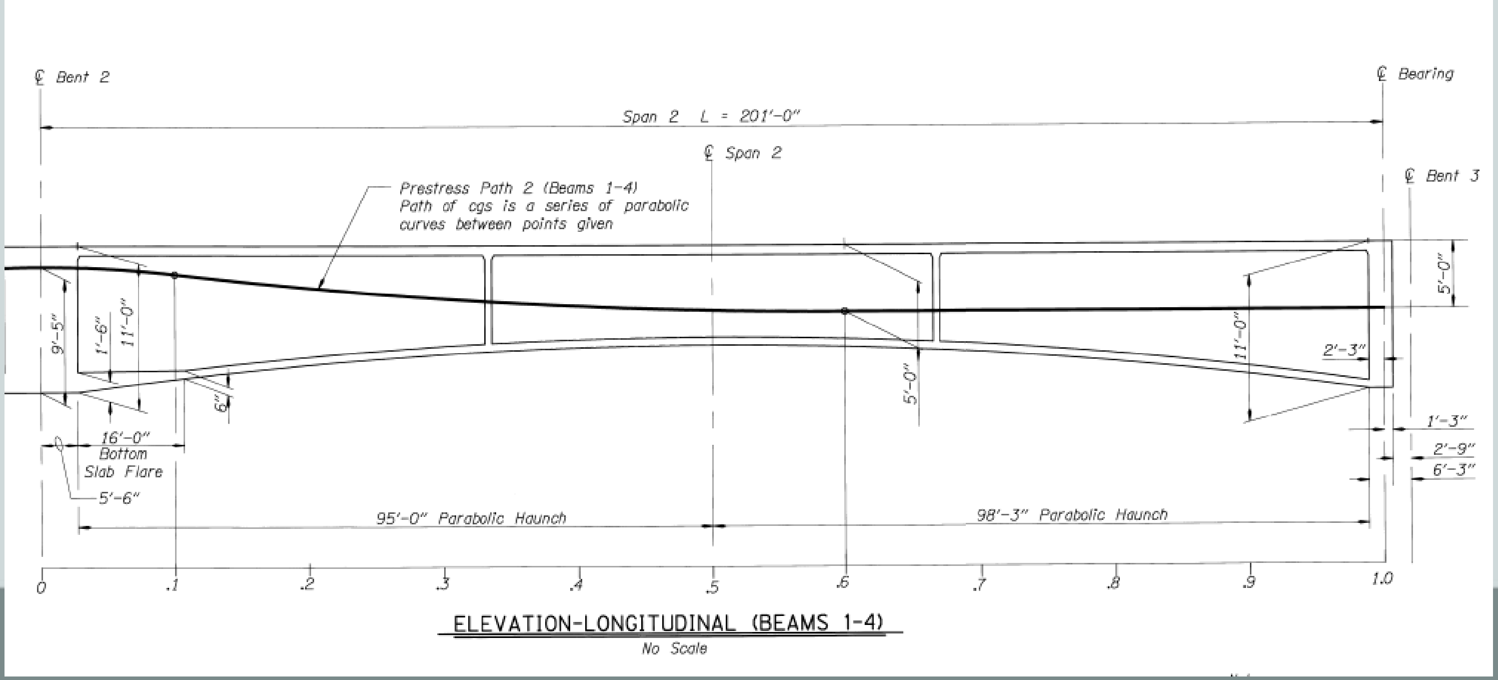
Bridge Foundation

- Crossbeam on 2 Column/Shaft foundation at Pier Bents
- 10 feet Diameter Drilled Shafts
- Precast Column Base

Drilled Shaft Casing Installation

Approach Spans

- 4 Cast-in-place post-tensioned approach spans, 2 each side of channel
- Approximate span length of 200 ft
- Parabolic structure depth varies from 7'-6" to 11'-0" ft
- Variable width structure
- Horizontally Curved near Island



Rebar and Post-Tensioning Ducts for Box Girder

Steel Tied Arch Channel Span

Benefits of the Steel Tied Arch

- Aesthetically pleasing
- Shallow depth over channel
- SHPO – portion of structure above deck
- Reduced number of piers in channel
- Increased width of navigation opening
- Coast Guard – no falsework in channel, minimal disruption to navigation

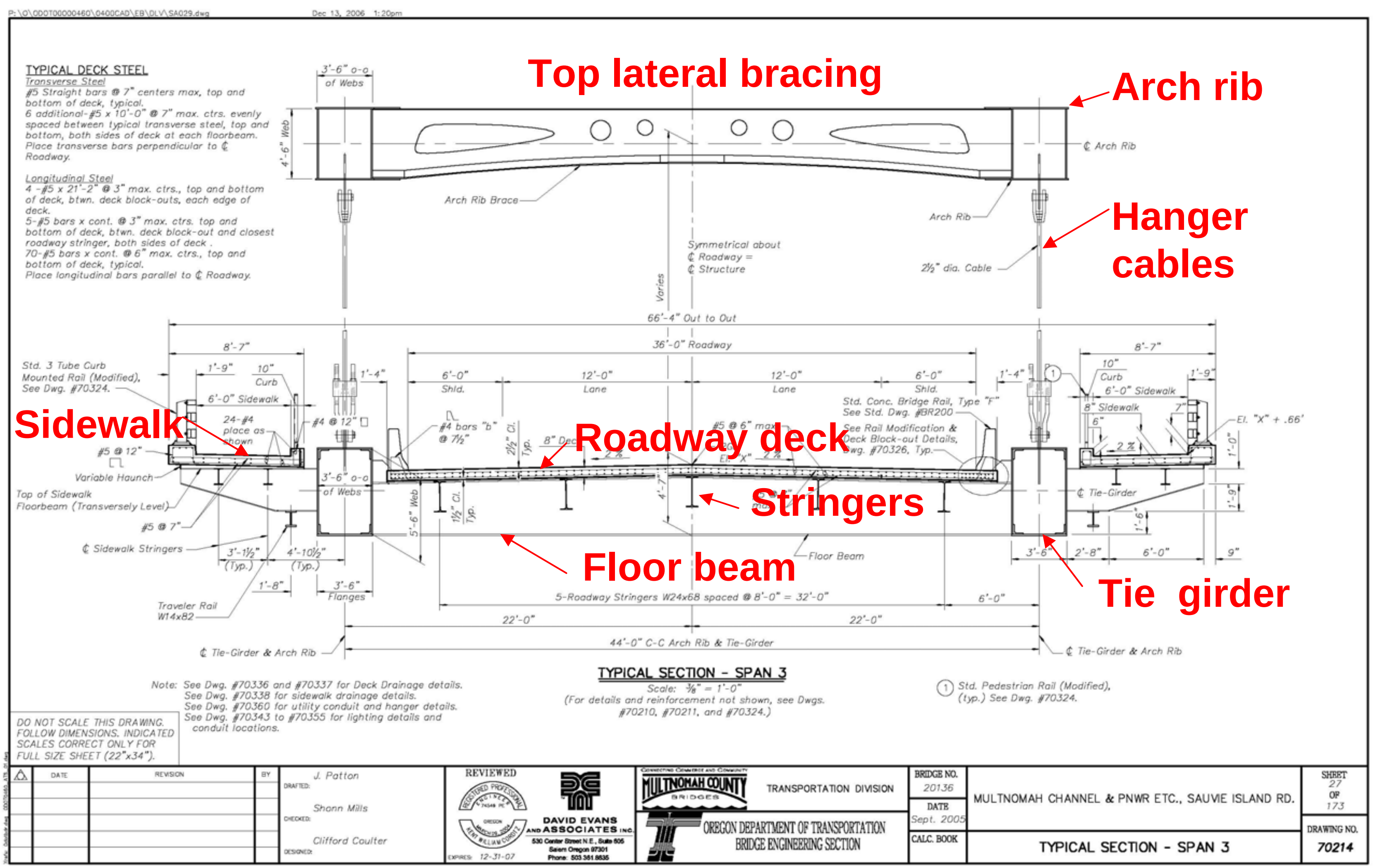
Features of Tied Arch Design

- Two methods of steel erection allowed
  - Cantilever erection with temporary towers and stays
  - Assemble offsite and float in
- A709 Grade 50W weathering steel with portions painted for extra corrosion protection
- Tie girders designated fracture-critical
- Hanger cables in "radial" pattern
- Cast-in-place concrete roadway deck and sidewalks

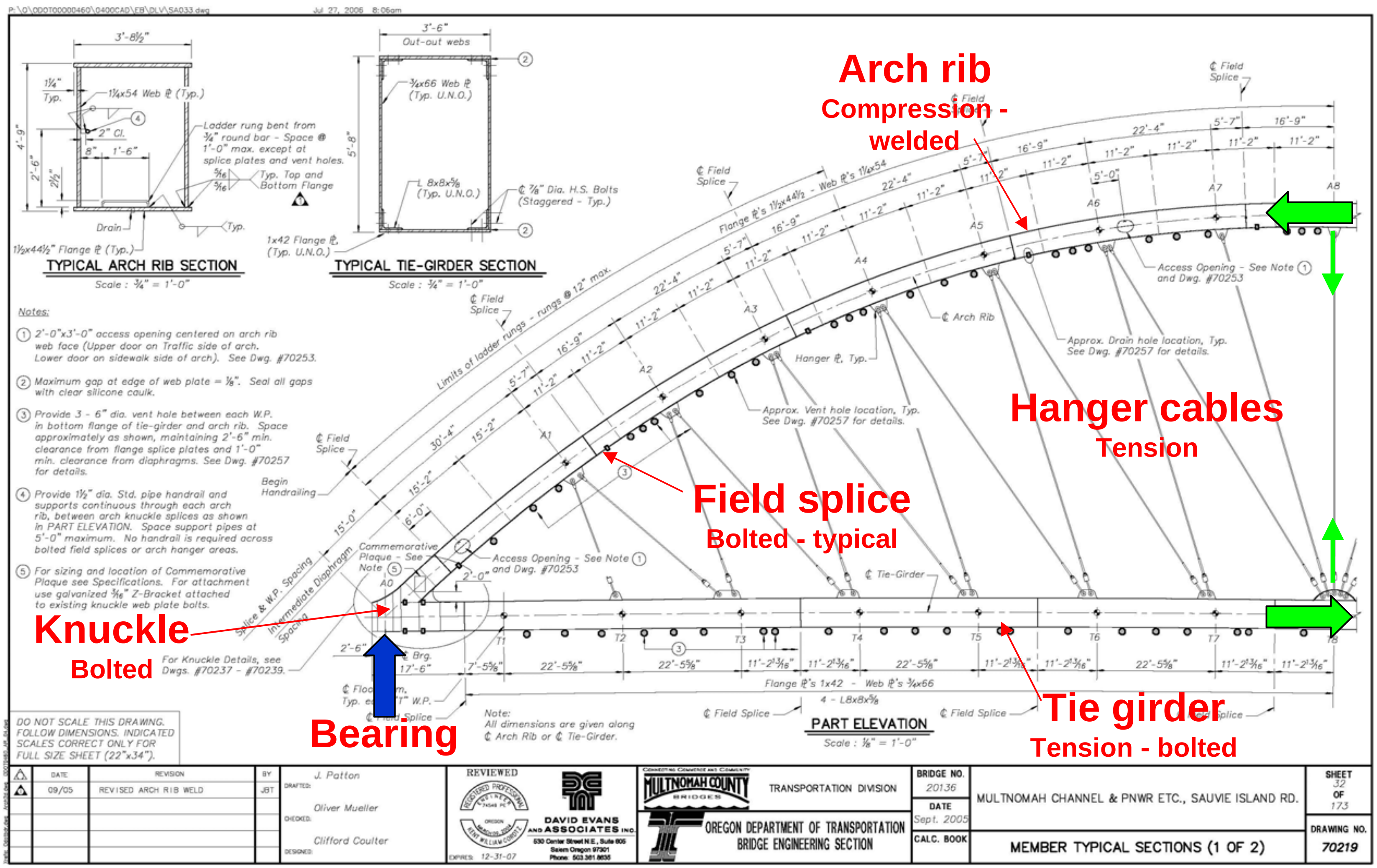
Steel Design

- AASHTO LRFD
- Permit loadings per ODOT and Multnomah County
- Arch rib geometry – minimize bending and live load deflection
- Hanger cables – maintain tension
- Redundancy
  - Tie girder – loss of plate or flange
  - Hanger cables – loss of any one cable
- Fatigue
  - Floor beam connection – prevent web distortion

Arch Span - Typical Section

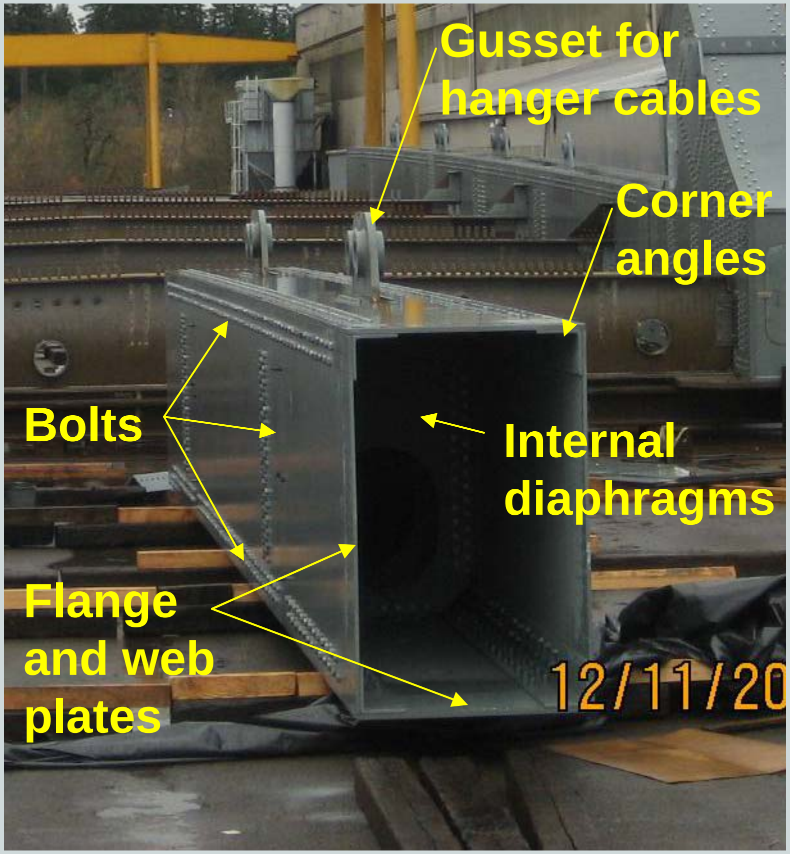


Arch Span - Part Elevation



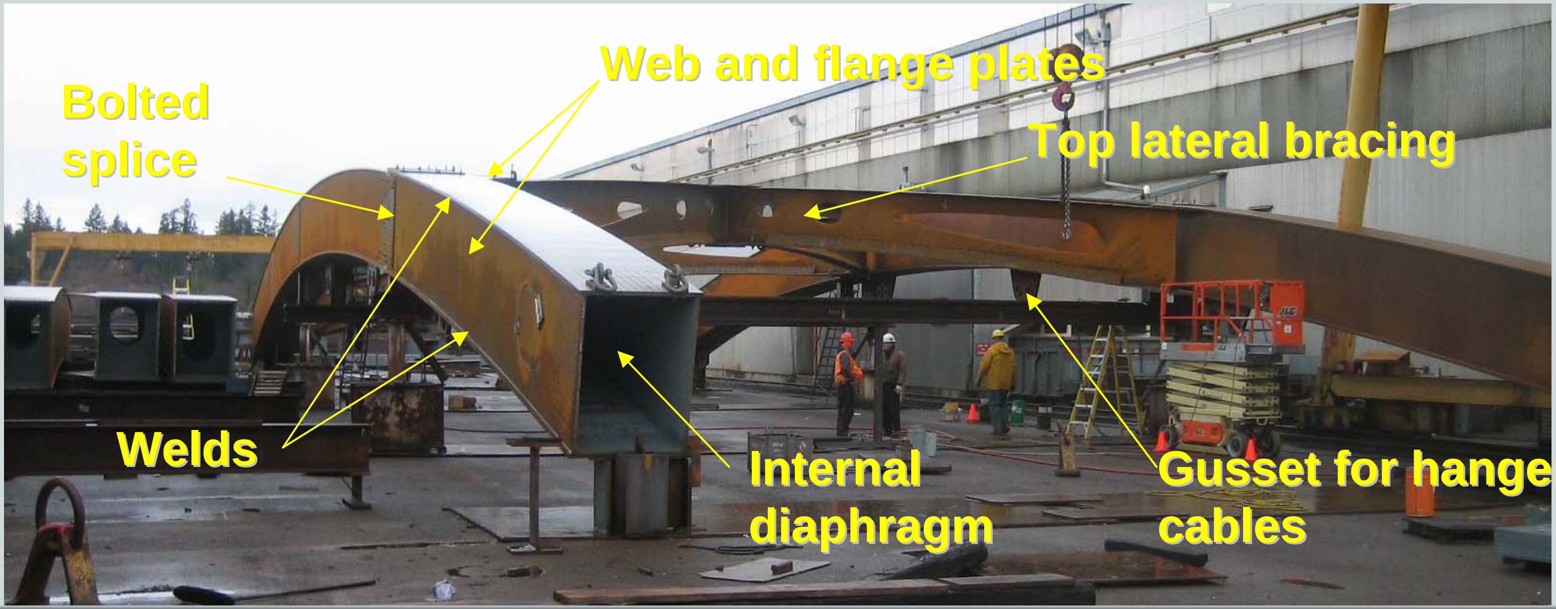
Tie Girders

- Tie girders designated fracture-critical
- Built-up steel box sections
- Connected by bolted corner angles
- No welding
- Designed for fracture of a web or flange plate – special Extreme Event load combination



Arch Ribs

- Welded steel box sections with bolted splices
- Geometry to minimize bending and live load deflection
- Shape driven by cable pattern behavior
- Sensitivity of cable forces to arch geometry



Hanger Cable Systems

Vertical cables

- **Simplicity**

Cross cables

- **Reduction in deflections and moments**

Radial cables

- **Aesthetics**

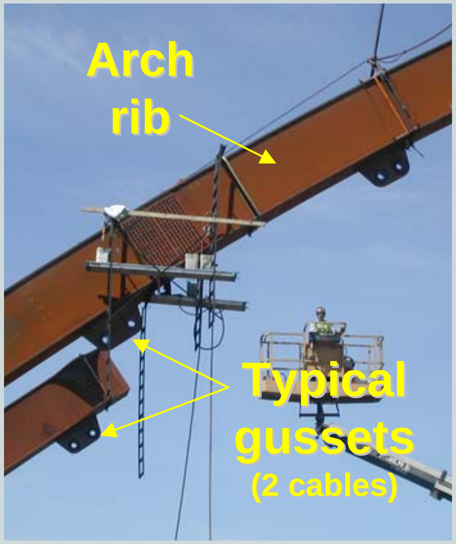
Vertical cables

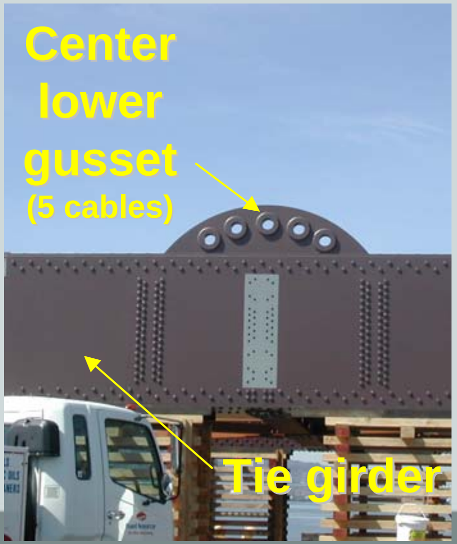
Cross cables (network)

Radial cables

Hanger Cables

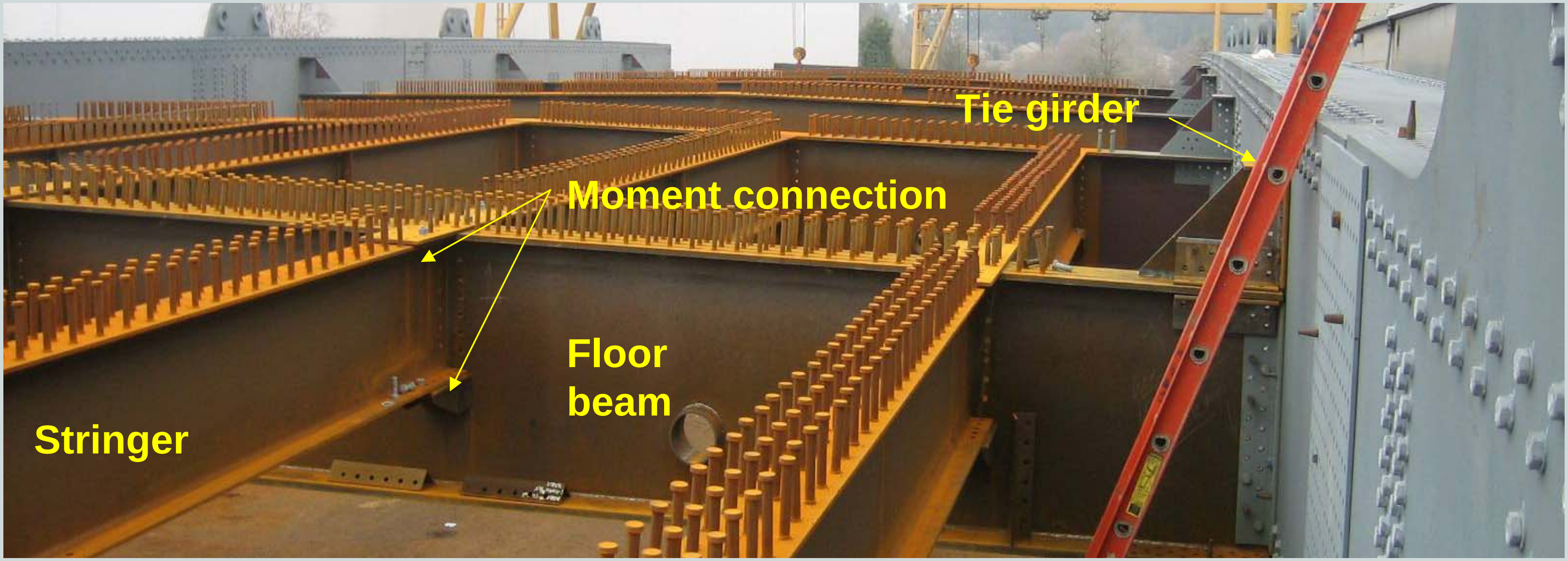
- Radial cable pattern - aesthetics
- 2-1/2" diameter structural strand
- ASTM A 586 Class A zinc coating
- Stressing from lower connection
- Installation sequence to maintain cables in tension under all loadings
- Designed for loss of any one cable





Floor System

- Longitudinal stringers – composite rolled sections
- Floor beams – composite welded plate girders located at hanger supports
- Shallow depth – stringers frame into floor beams with moment connections



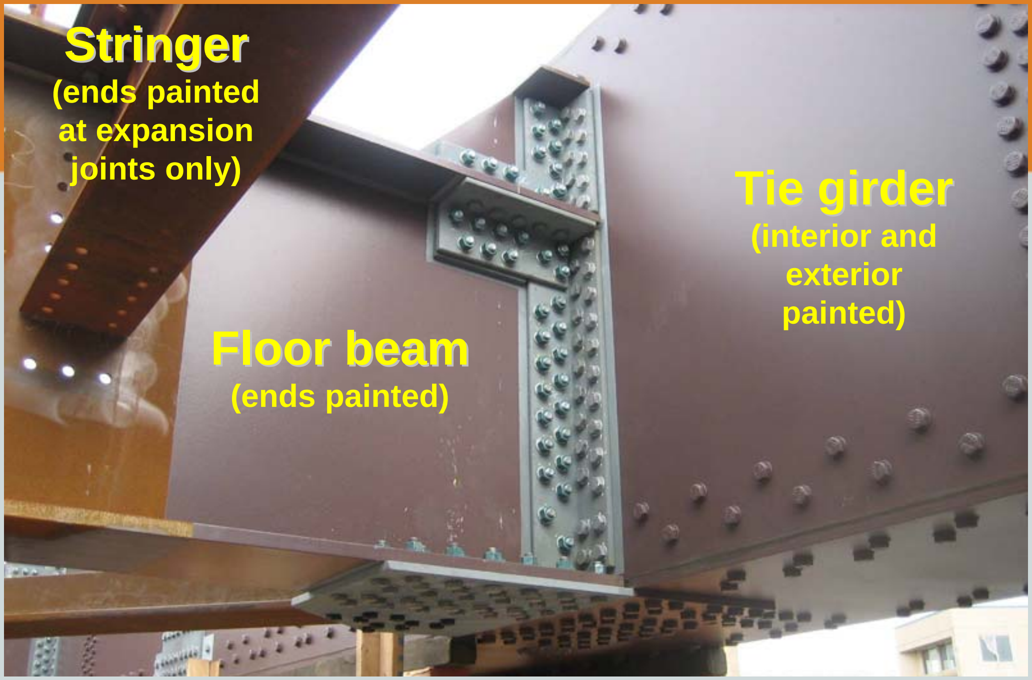
Lateral Bracing

- Bottom lateral bracing – WT sections in a "K" pattern
- Top lateral bracing – aesthetics
  - Variable depth "I" sections in a diamond pattern
  - Web cutouts

Arch ribs and top lateral bracing

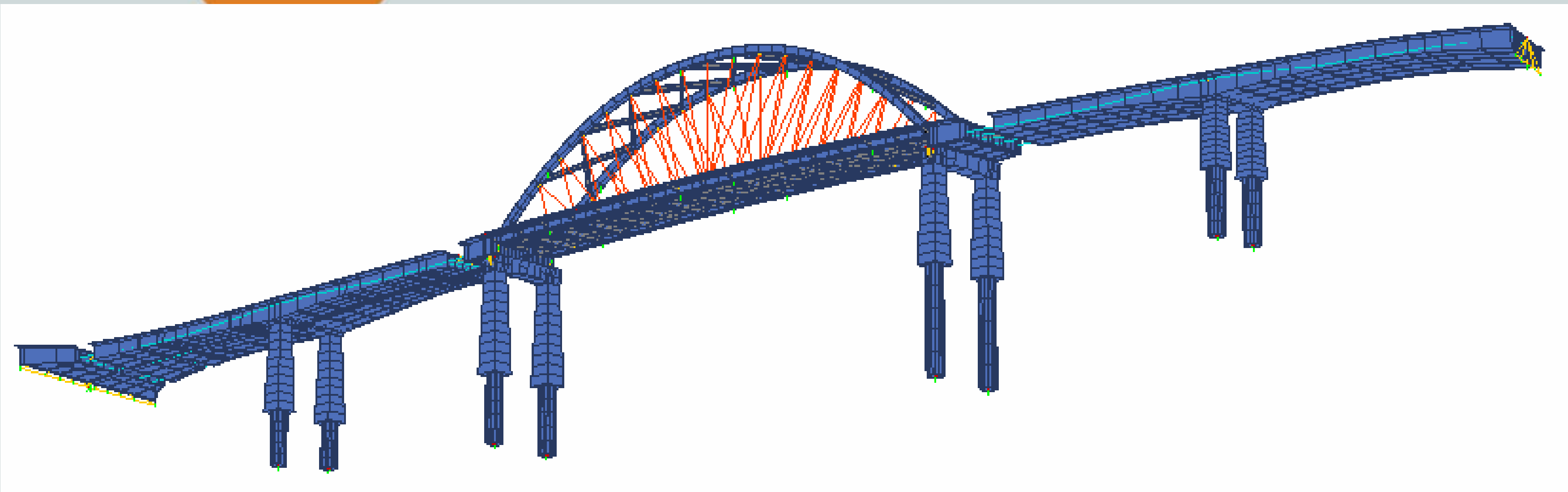
Top lateral brace section

Corrosion Protection



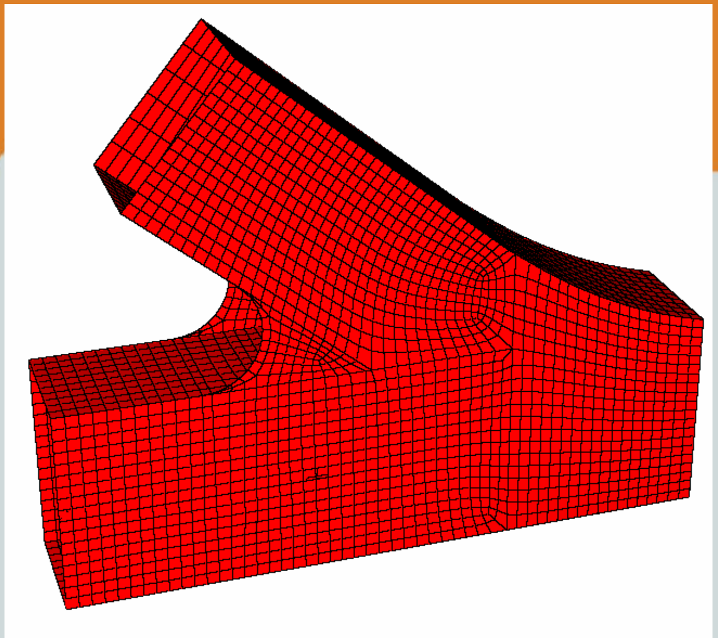
- Project goal – minimize maintenance
  - Weathering steel
- Corrosion protection
  - Paint critical locations
  - Provide drains and vents in box sections
  - Caulk critical locations
  - Galvanized hanger cables, sockets, stirrup rods, and pins

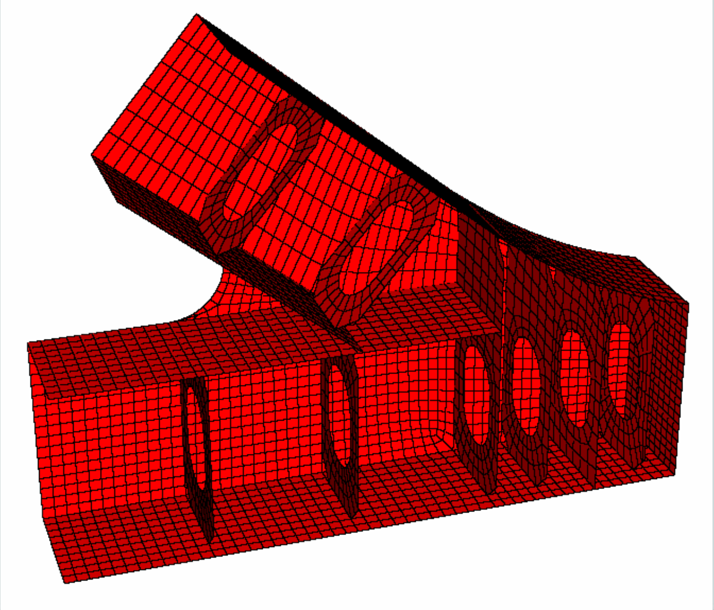
Global Analysis



- Performed using RM2000
- Construction stage analysis
- Live load, wind, thermal and seismic

Local Analysis





- Detailed finite element analysis of arch knuckle
- Performed using ABAQUS

Structure Data

- Bridge costs: $26,400,000 including removal and temporary works
- Main span: 365 feet
- Steel tonnage: 1250 tons
- Steel weight: 102 lbs per sq. ft. of deck
- Arch rib
  - Span to rise ratio = 4.7
  - Span to depth ratio = 76 (based on access req'ts)
- Tie girder
  - Span to depth ratio = 63

Shop Fabrication

Fought & Company

Knuckle Fabrication

Arch Assembly & Transportation

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Setting Tie Girder Section

Setting Girder on Timber Cribbing

First Arch Rib Sections

Arch Rib Sections and Bracing

Arch Ribs and Support Struts

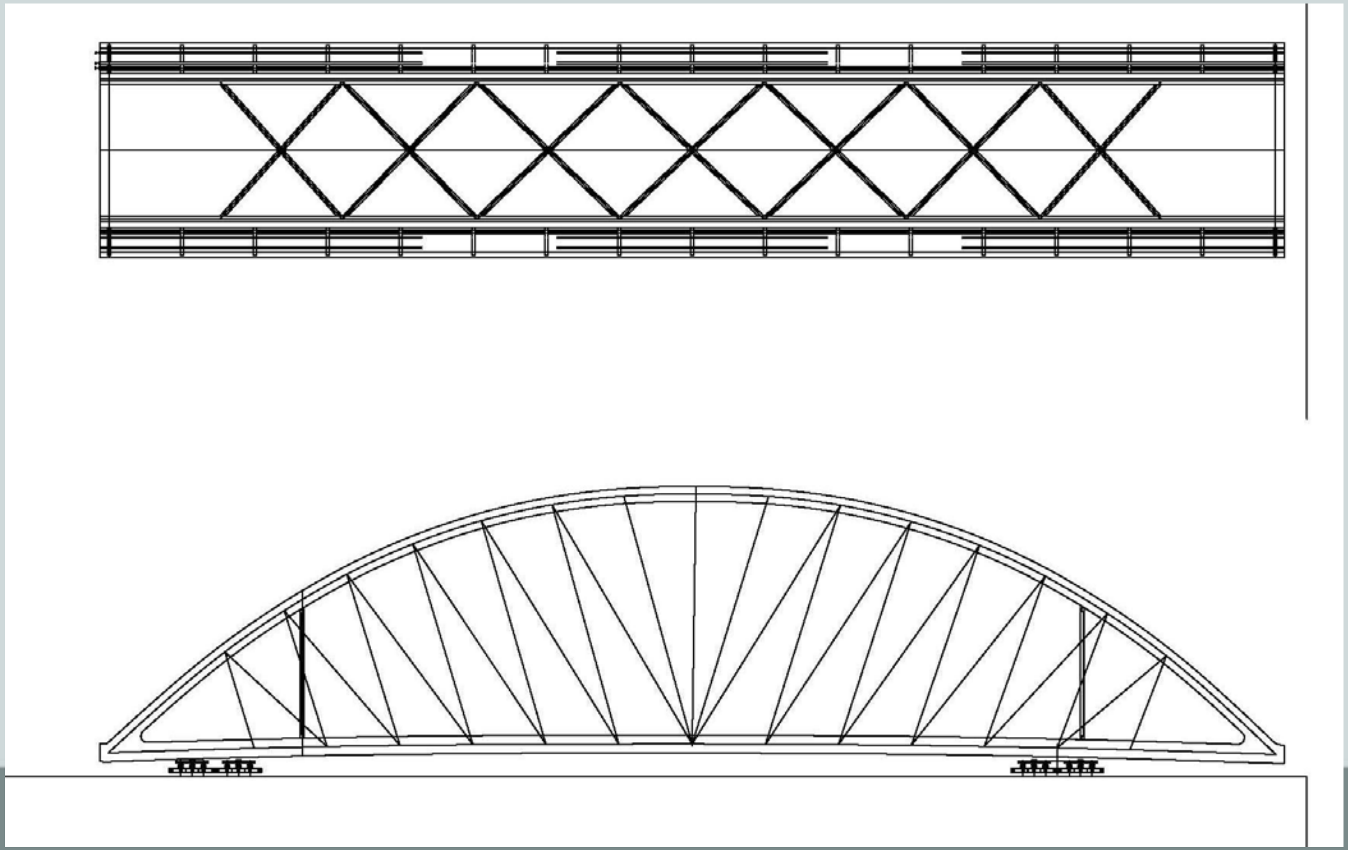
Assembling Arch Rib Splice

Arch System Nearing Completion

Erecting Arch Rib Closure Piece

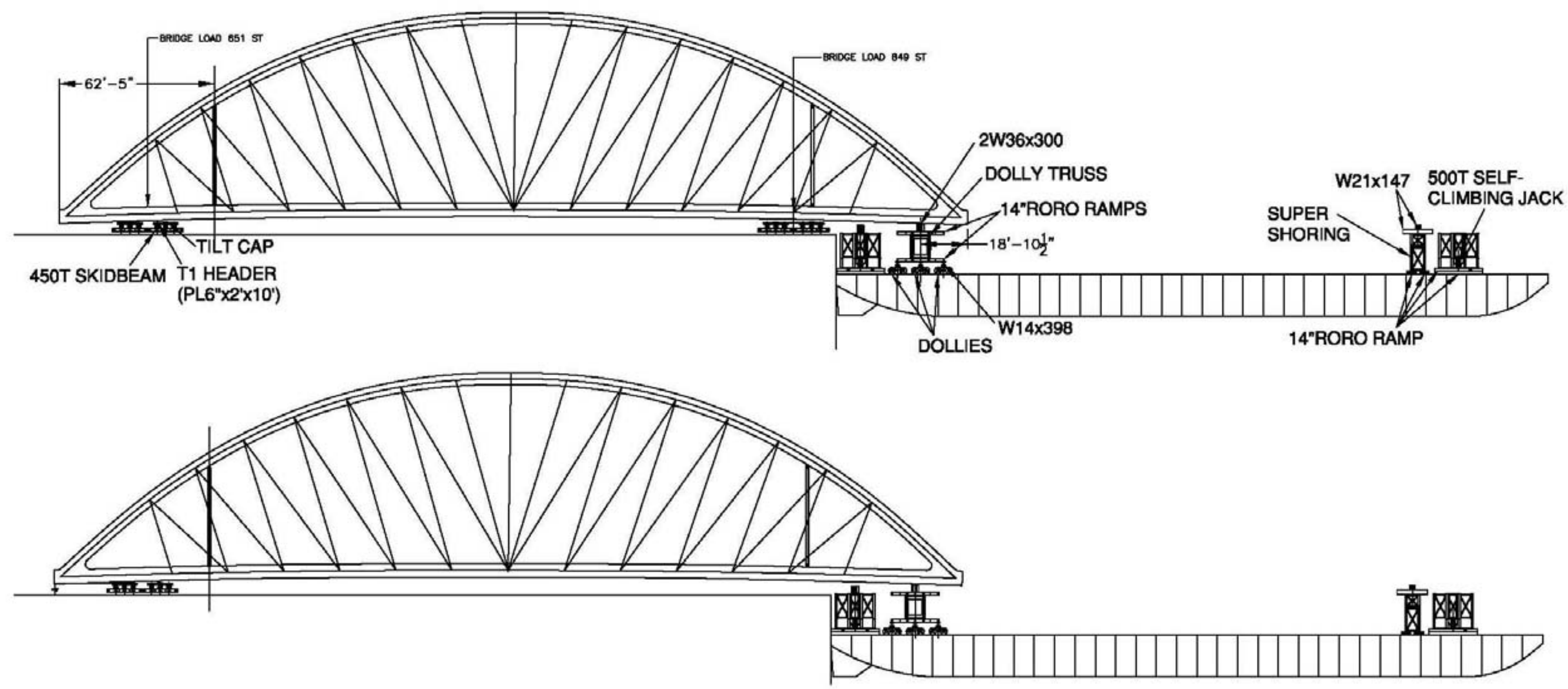
Load-out and Jack-up Process

- The following slides are used by permission from Norsar, LLC, Everett, WA
- Process to move erected arch about 8 miles from Port of Portland Terminal 2 to Sauvie Island.



Load-out

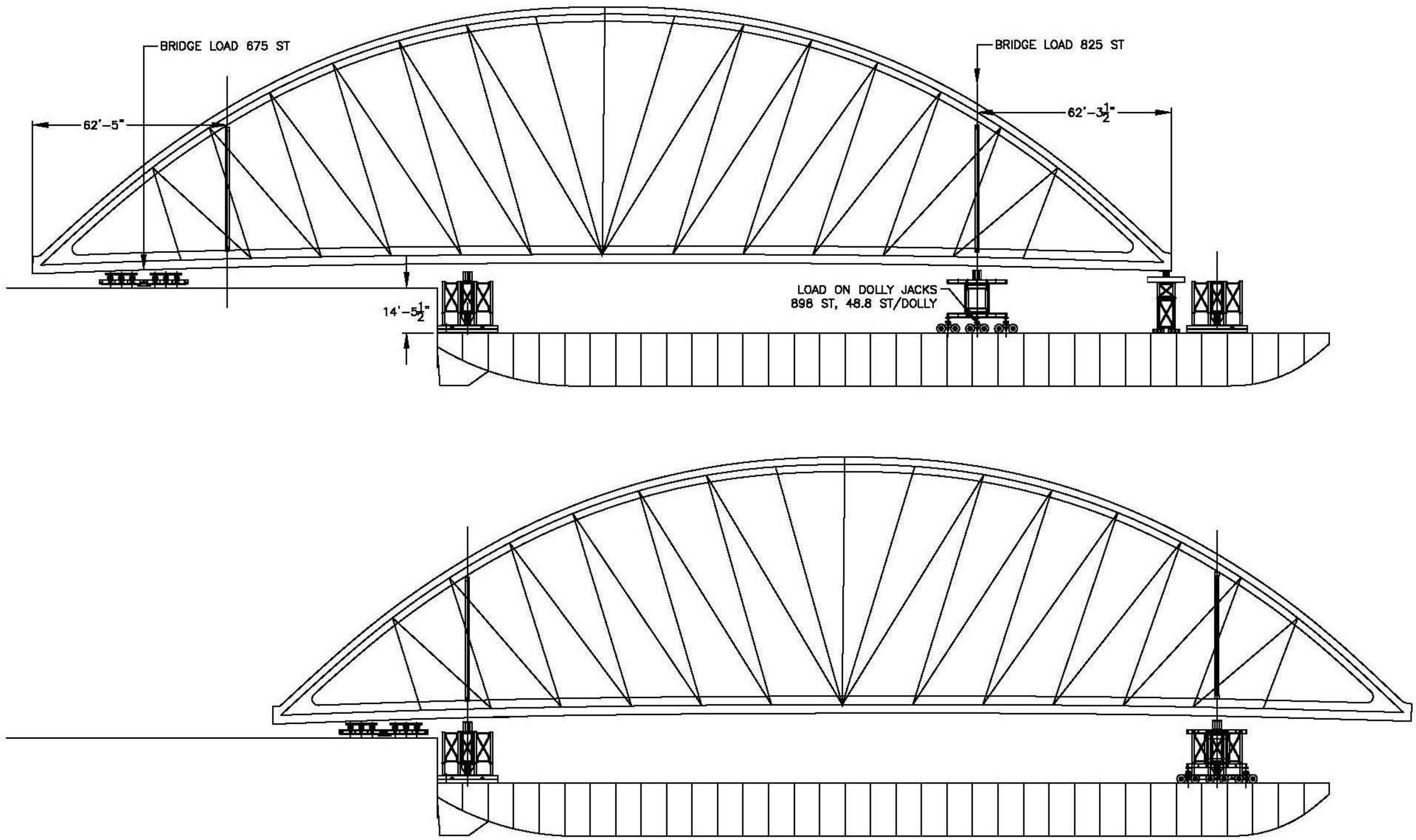
- Skid forward until over dolly truss, then transfer load



Skidding Equipment in Use

Dolly Equipment

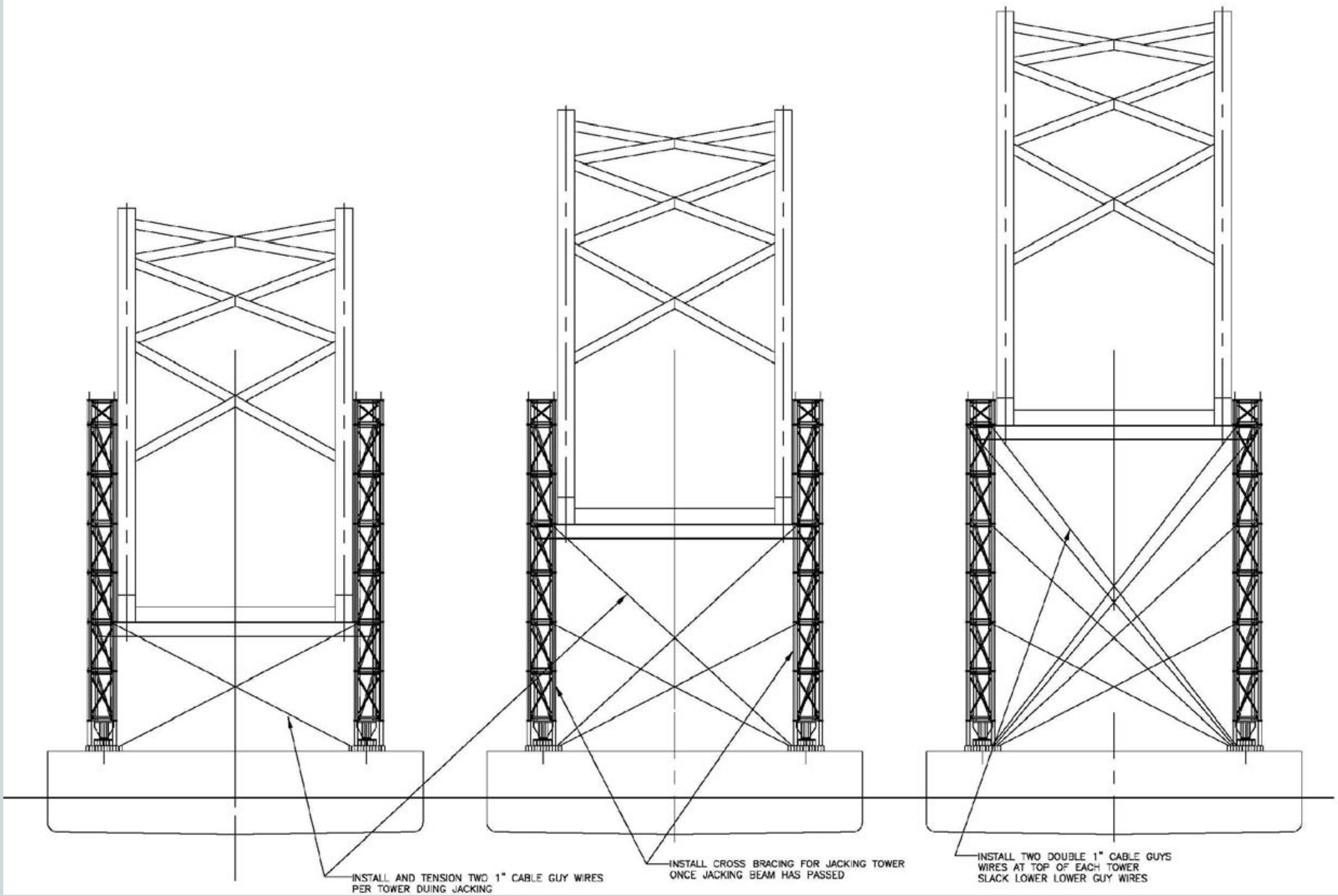
Loaded out



BRIDGE LOAD 675 ST
BRIDGE LOAD 825 ST
62'-5"
62'-3½"
14'-5½"
LOAD ON DOLLY JACKS
898 ST, 48.8 ST/DOLLY

Shoring and Jacking frame

Jack-up

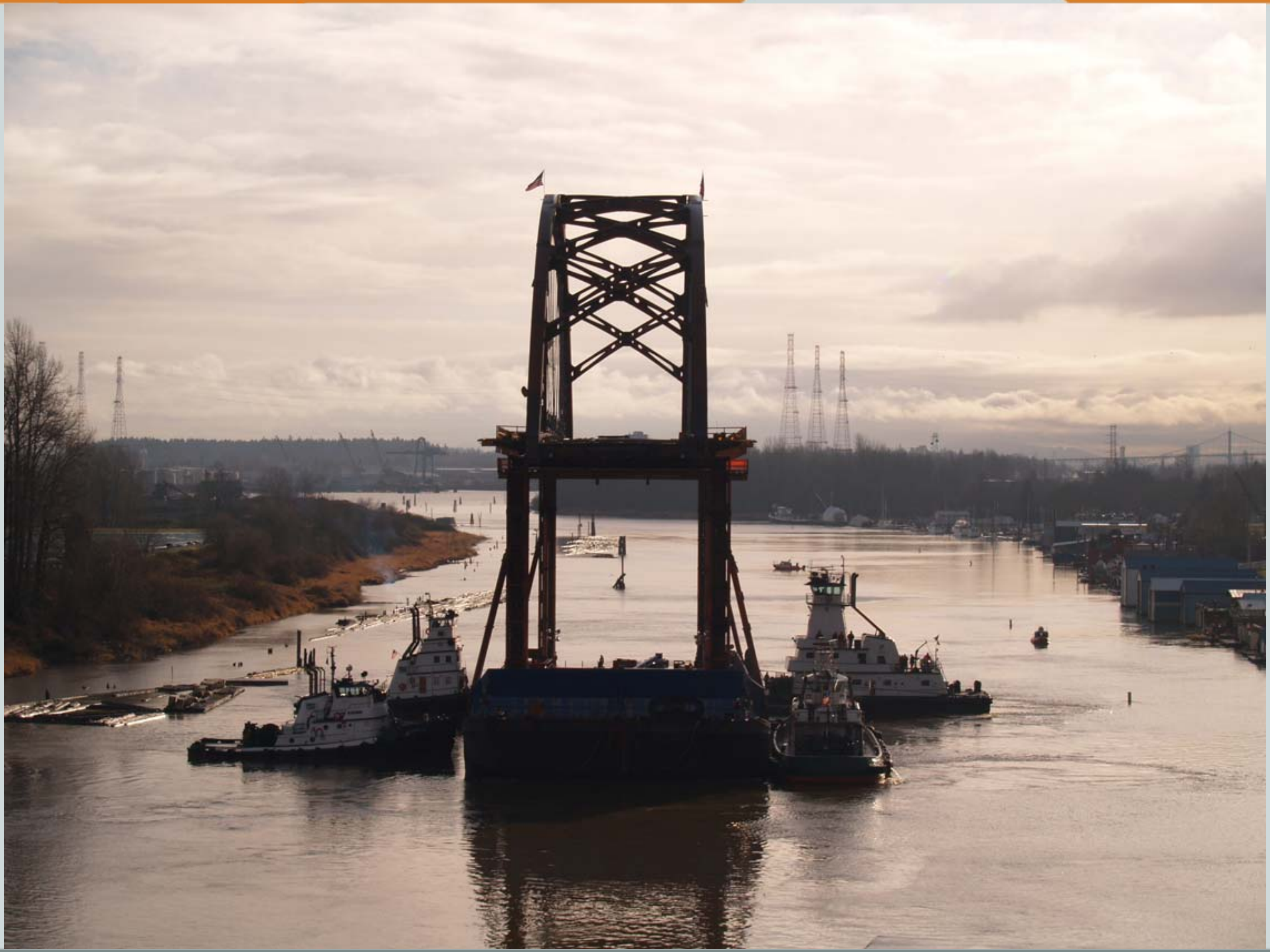

INSTALL AND TENSION TWO 1" CABLE GUY WIRES PER TOWER DUING JACKING
INSTALL CROSS BRACING FOR JACKING TOWER ONCE JACKING BEAM HAS PASSED
INSTALL TWO DOUBLE 1" CABLE GUYS WIRES AT TOP OF EACH TOWER SLACK LOWER LOWER GUY WIRES

Transportation to Island

Departure From Terminal 2

Leaving Portland

Nearing Bridge Site



Positioning into Final Location

Lowering onto Bents

Completed Structure