Sellwood Replacement Bridge

Perched Box Caisson

Design & Construction

…a cofferdam alternative

McGee Engineering Inc.

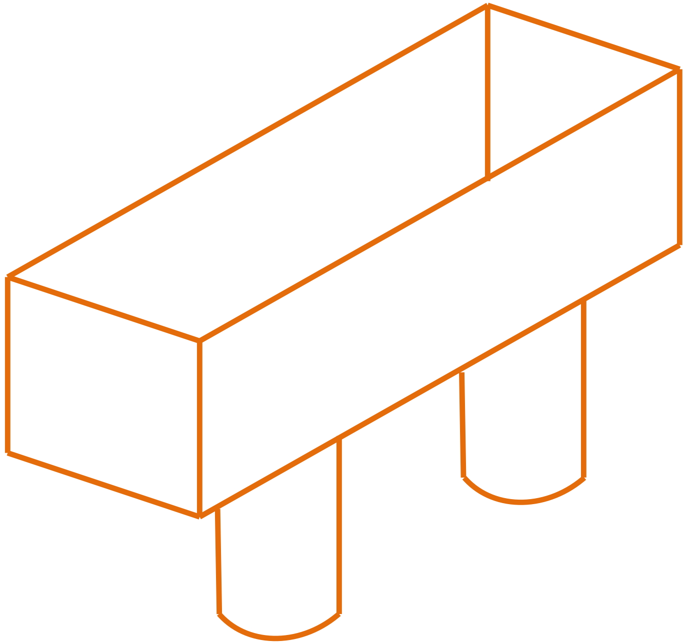
Sellwood Replacement Bridge

Project Information

- Location: Portland, Oregon
- Budget: $307.5 Million
- Three span steel deck arch (Design by TYLin)
- Contractor: Slayden/Sundt, A Joint Venture

Perched Box Caisson

Elevated cofferdam constructed above water then lowered down using hydraulic jacks. A voided base slab sleeves over foundation shafts as the box is submerged and secured using anchoring collars to seal and resist vertical forces.



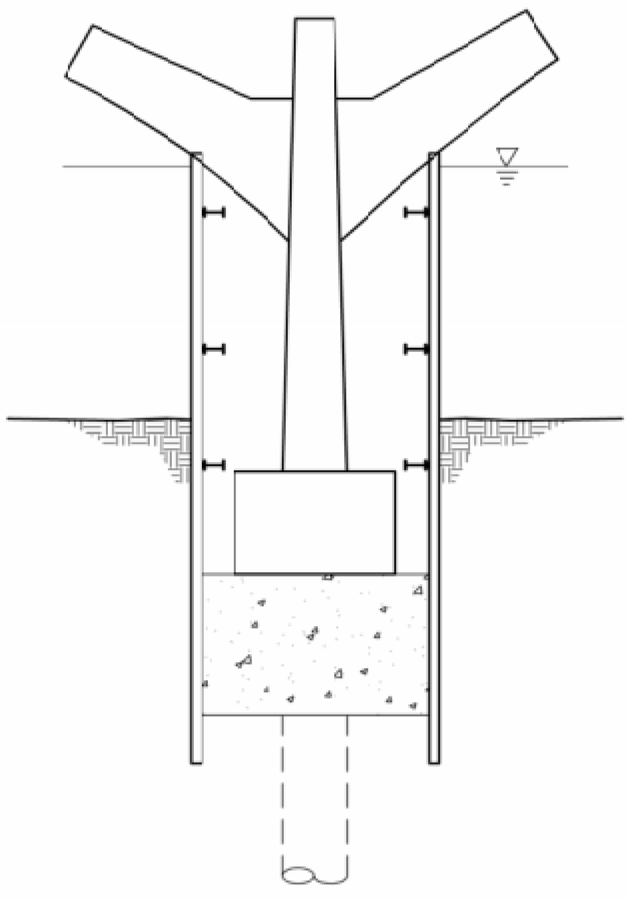
Why?

Key Constraints

- Alluvial gravel with numerous cobbles and boulders up to 5 feet in diameter
- Long sheet pile length
- Scour up to 65 feet (CH2M Hill estimate)
- Stay-in-place falsework not to exceed 35ft^2 relative to stream flow
- In-water work restricted to July 1st - Oct 31st

Design Development

Buried Pier - Option 1
Typical Cofferdam



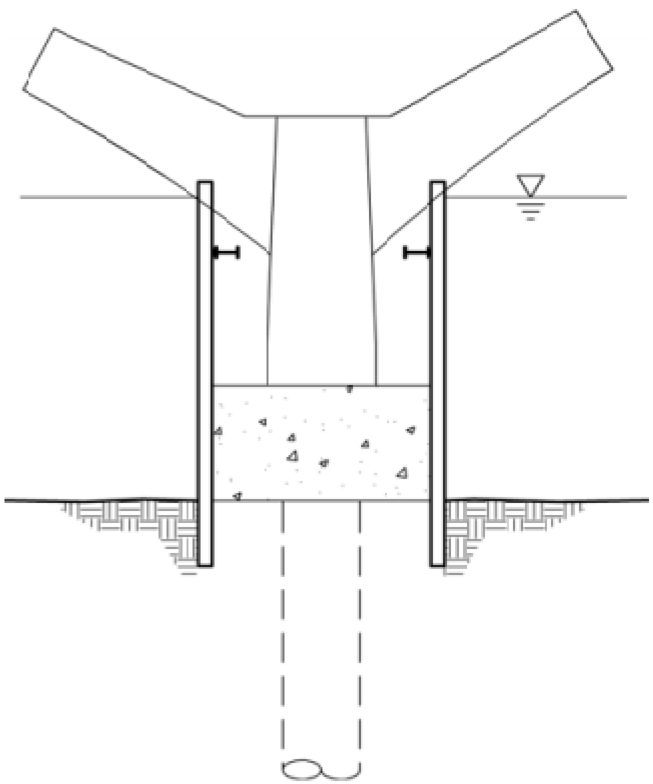
Constructability Limitations

- 90ft sheet piles driven into cobbles & boulders.
- In-water work

Conclusion:

NOT CONSTRUCTIBLE

Elevated Pier - Option 2A
Above Grade Seal



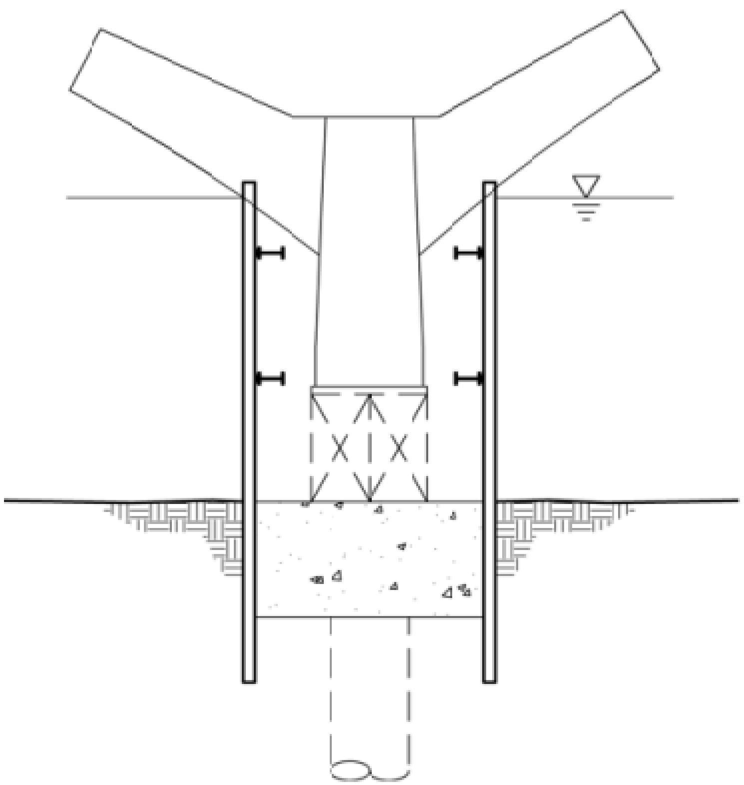
Constructability Limitations

- Abandoned concrete seal exceeds permit allowance
- Removal of concrete seal not reasonable.

Conclusion:

<u>NOT ALLOWED</u>

Elevated Pier - Option 2B
Cofferdam with Shored Pier



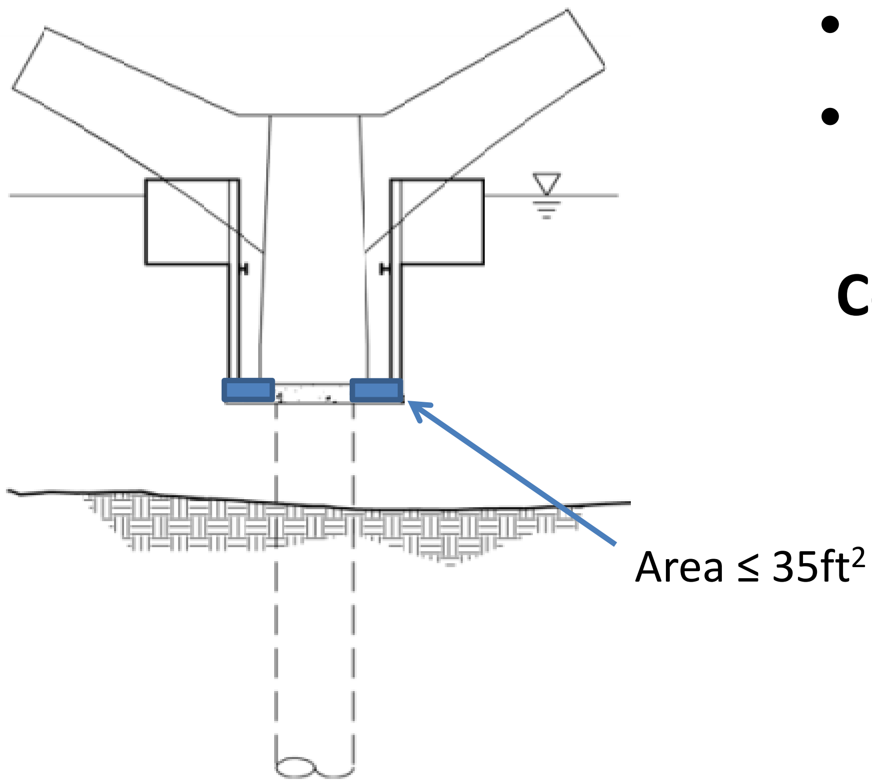
Constructability Limitations

- Piles driveability issues.
- Limited removal access of heavy falsework shoring.
- Mid depth concrete seal could negatively influence the structural behavior of the permanent foundations (i.e. Seismic Response)

Conclusion:

<u>NOT RECOMMENDED</u>

Elevated Pier - Option 2C
Perched Box Caisson



Constructability Limitations

- Fabrication Intensive
- Requires "Birds Mouth" Forms

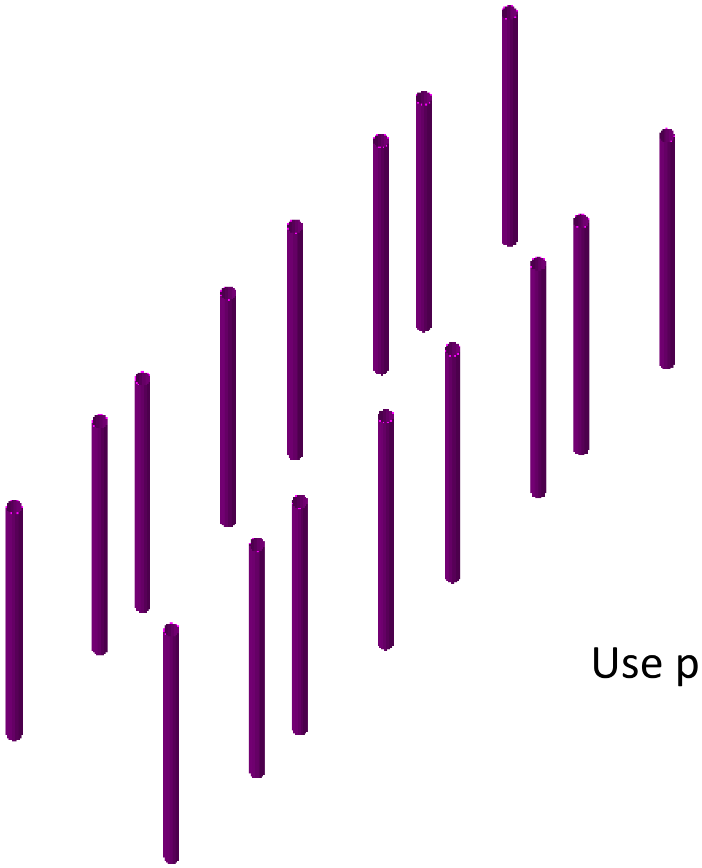
Conclusion:

<u>SELECTED OPTION</u>

Construction Sequence

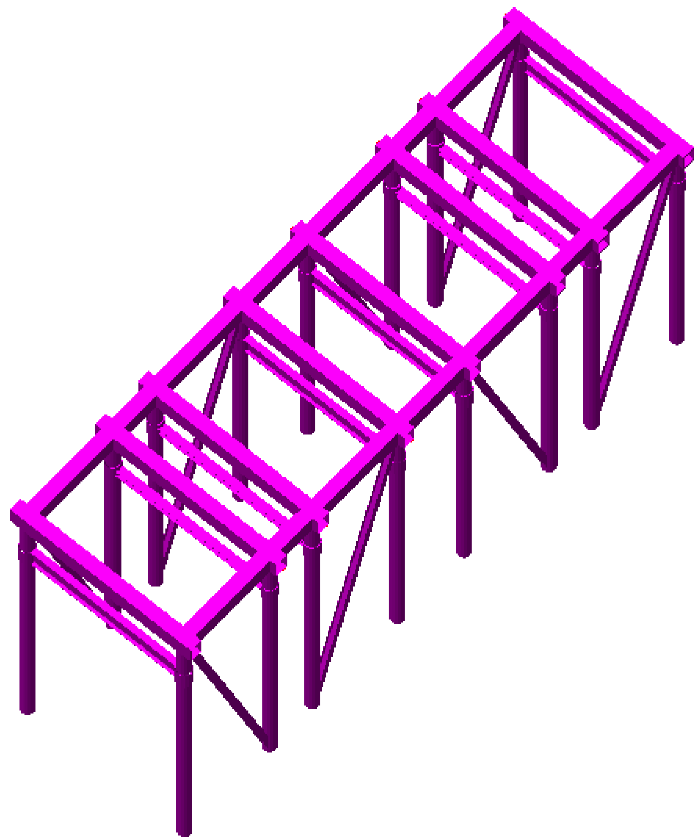
1,2,3,4,5

Drive Pile

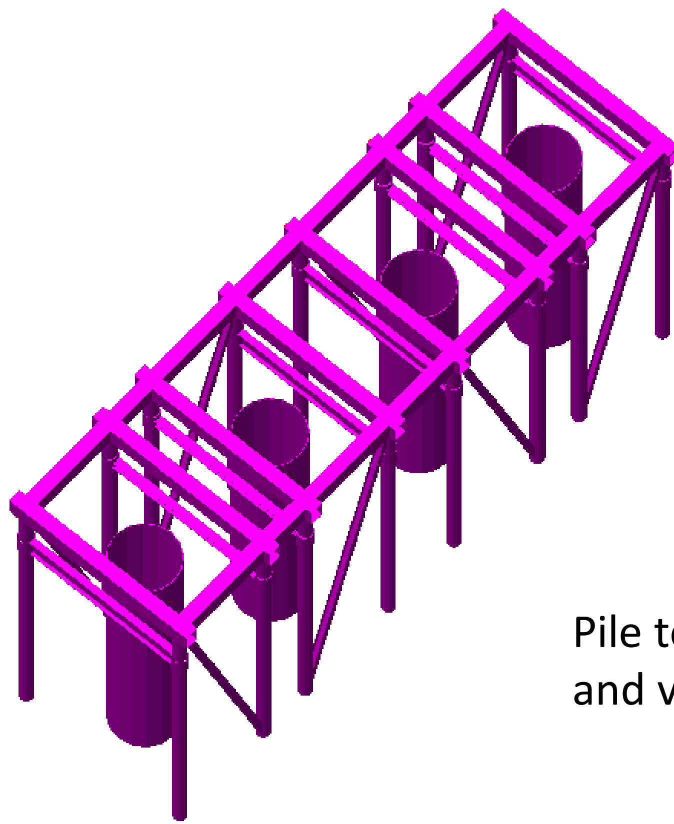


Use pile template when driving

Construct Drilling Reaction Frame

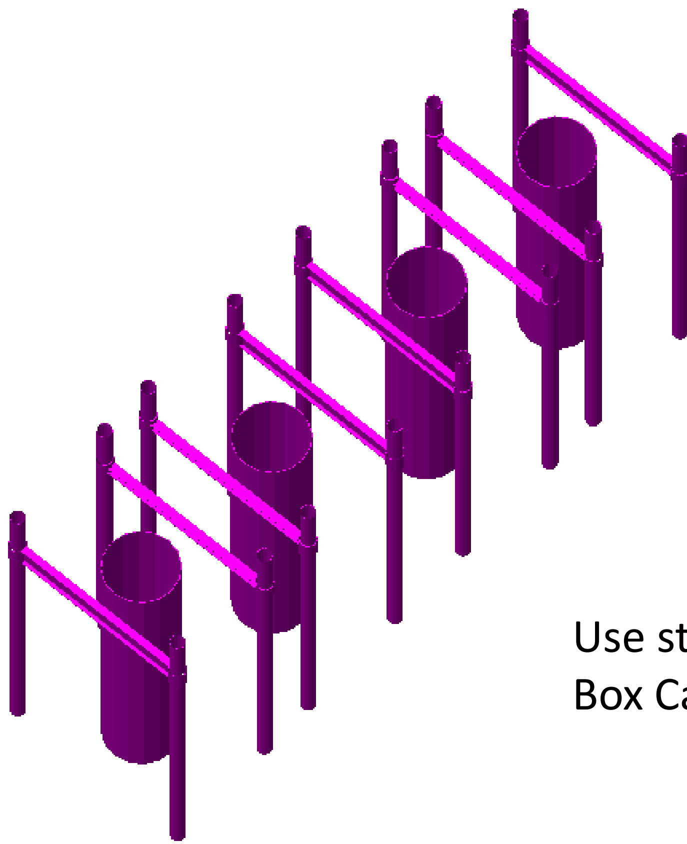


Install Drilled Shafts



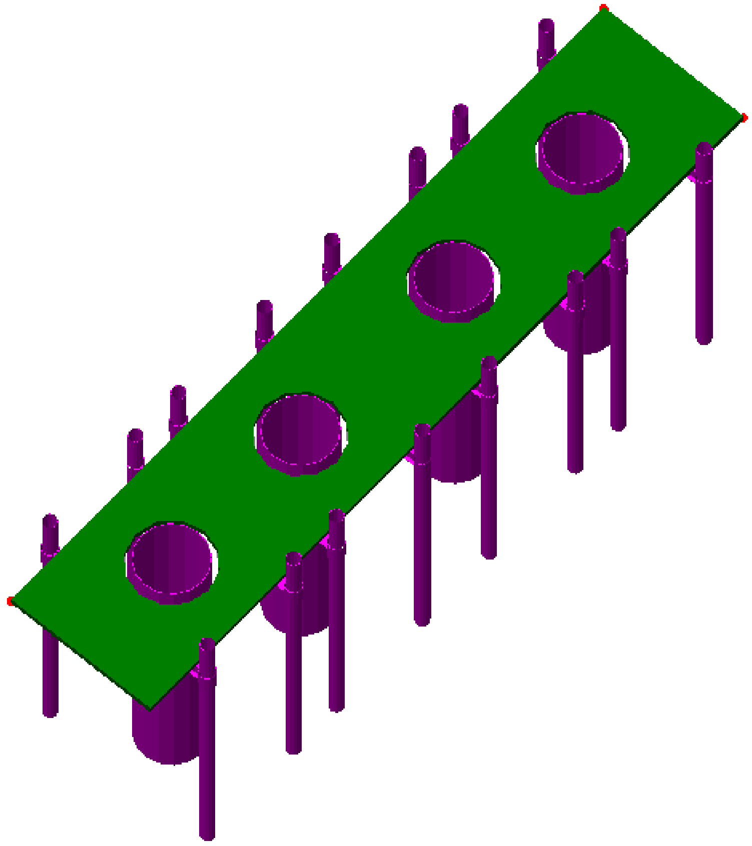
Pile to support oscillator lateral and vertical extraction forces

Disassemble Reaction Frame

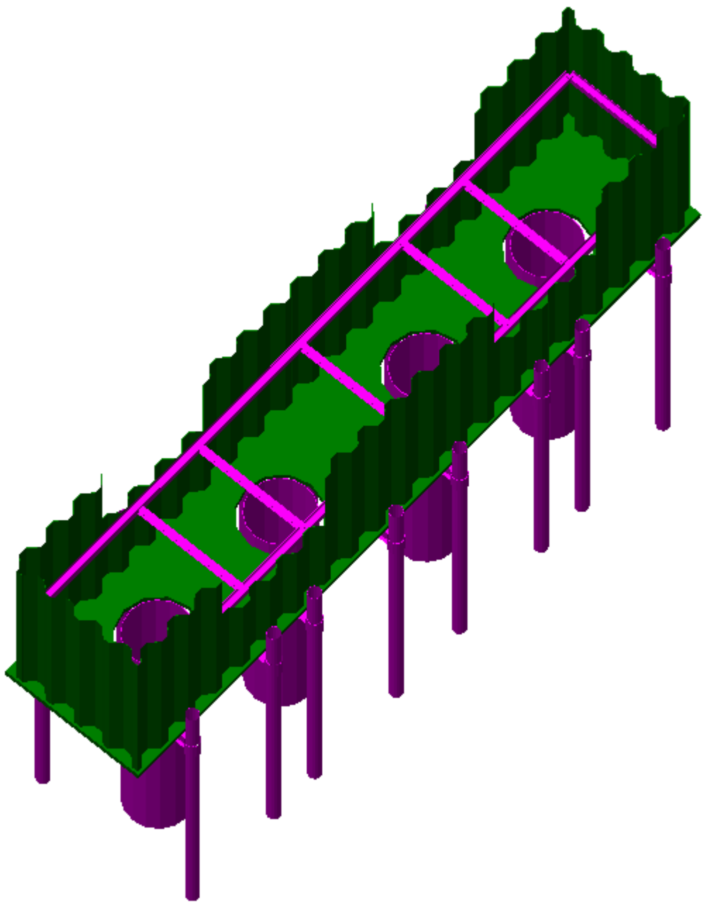


Use steel crossbeams to form Box Caisson base slab

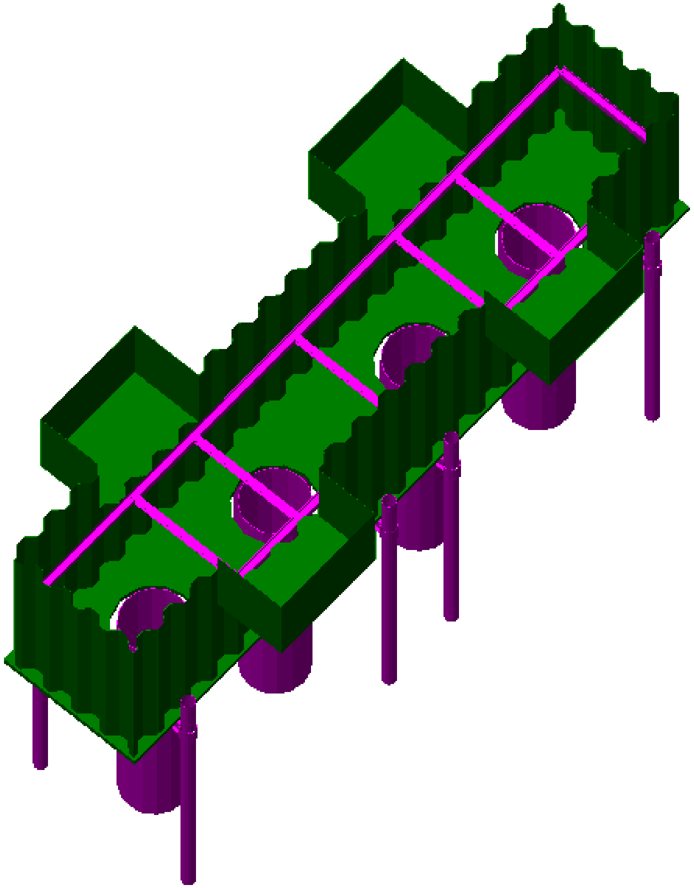
Pour Elevated Base Slab



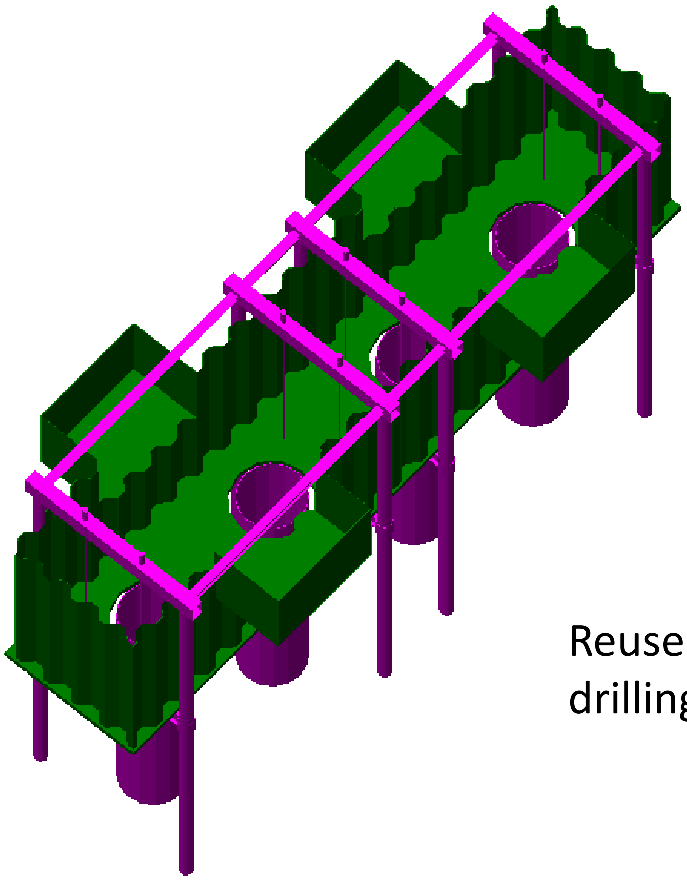
Construct Wales, Walls & Topping Slab



Construct Bird Mouth Forms

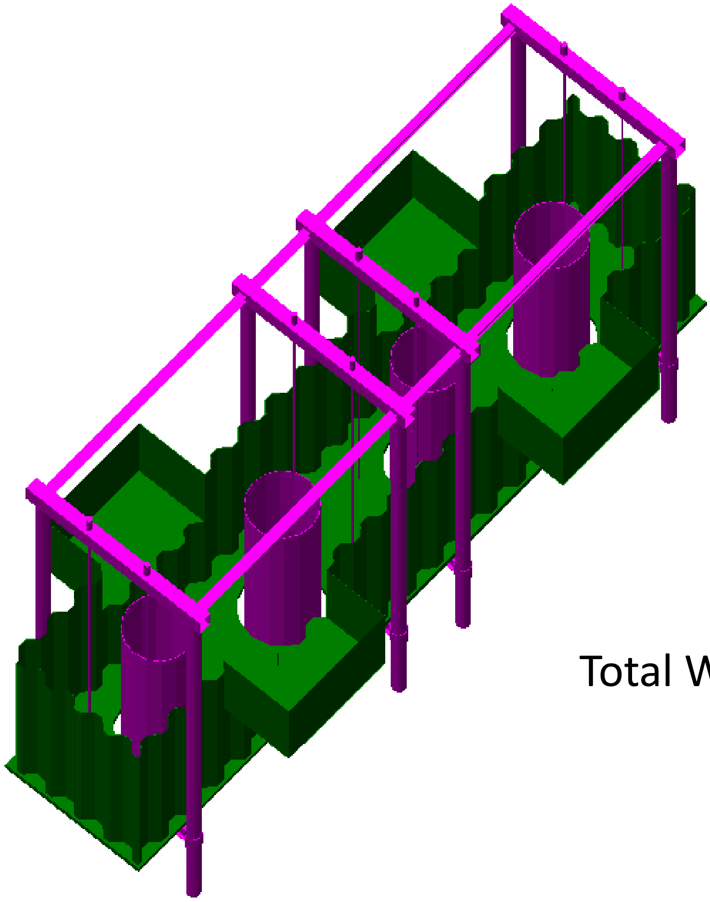


Construct Jack-Down Frame



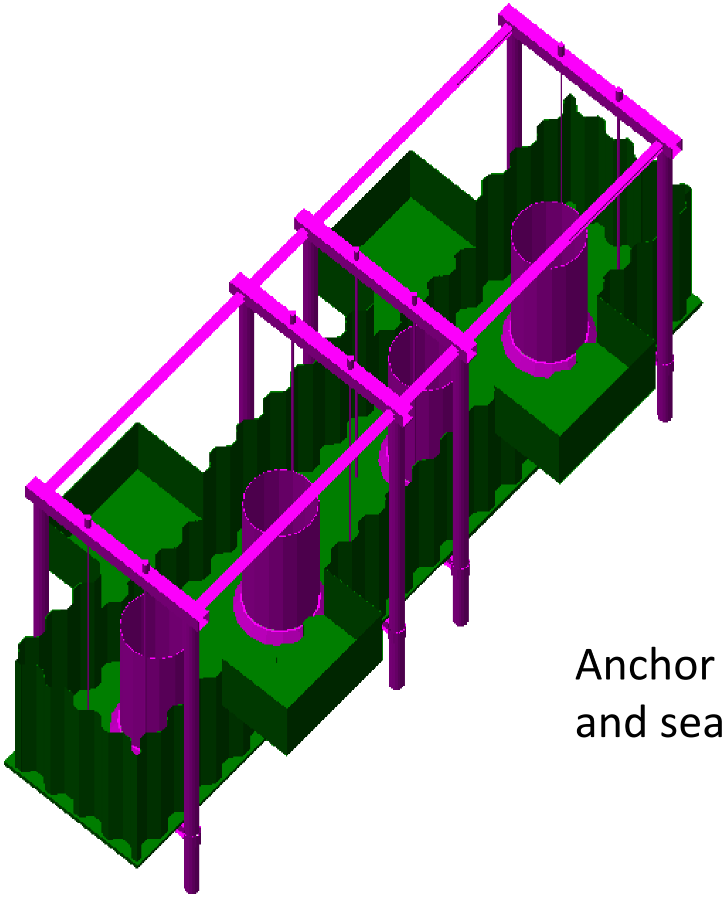
Reuse steel beams from drilling reaction frame

Lower Assembly (Jack-down)



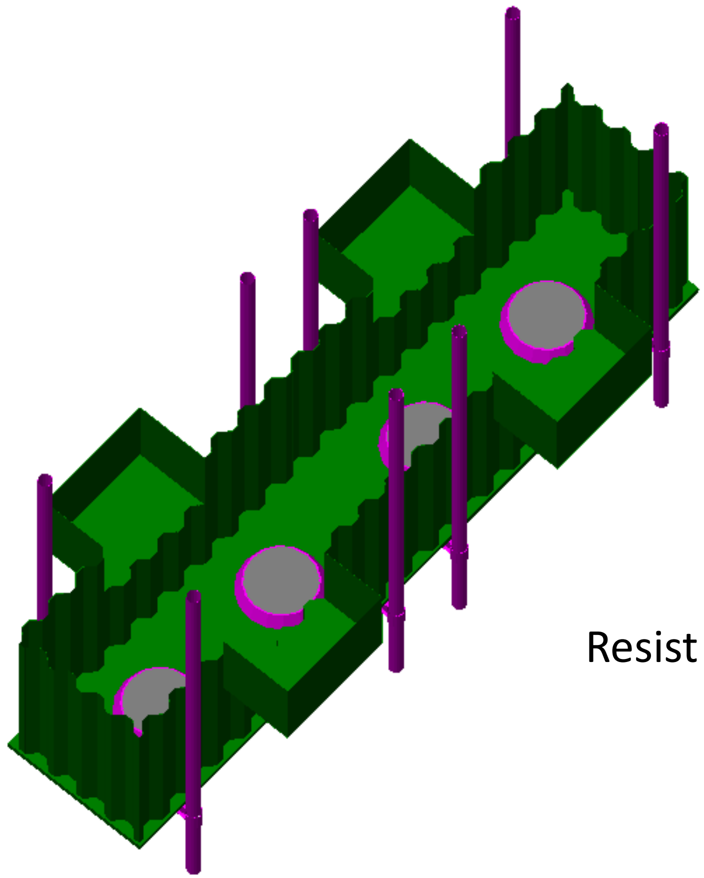
Total Weight = 1,016,000 lbs

Install Tie-down Collars



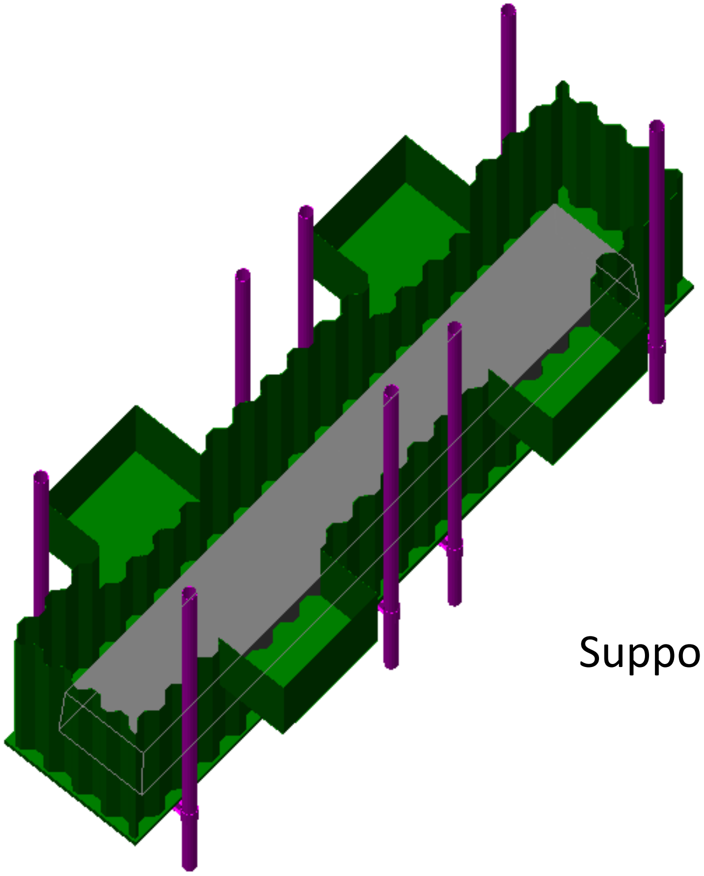
Anchor tie-down collars
and seal to shaft casing

Dewater, Remove Frame, Cut-off Casing



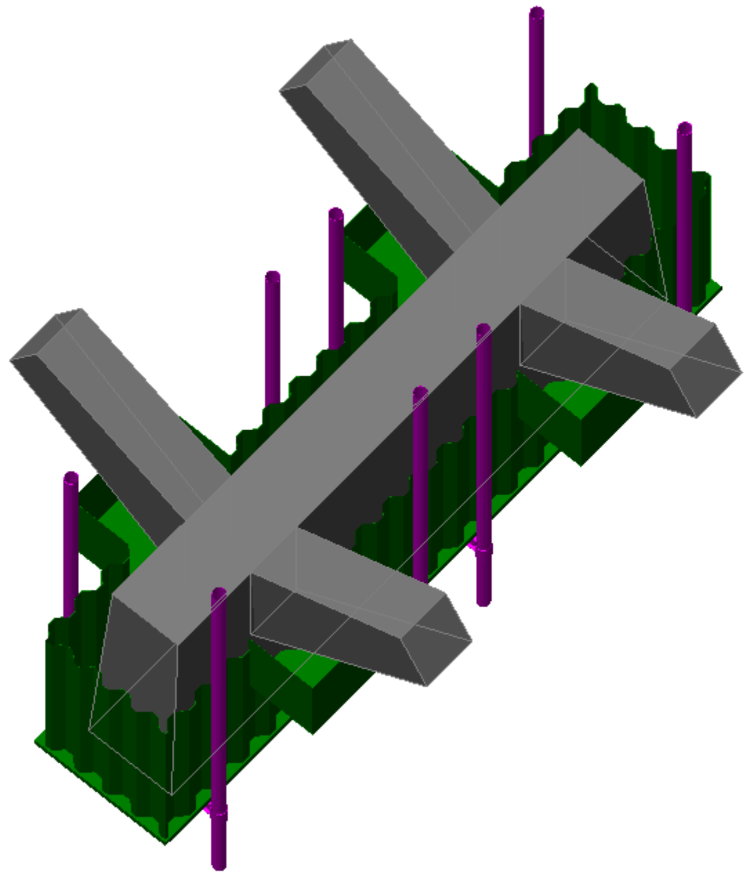
Resist buoyant uplift force

Pour Bottom Lift of Pier

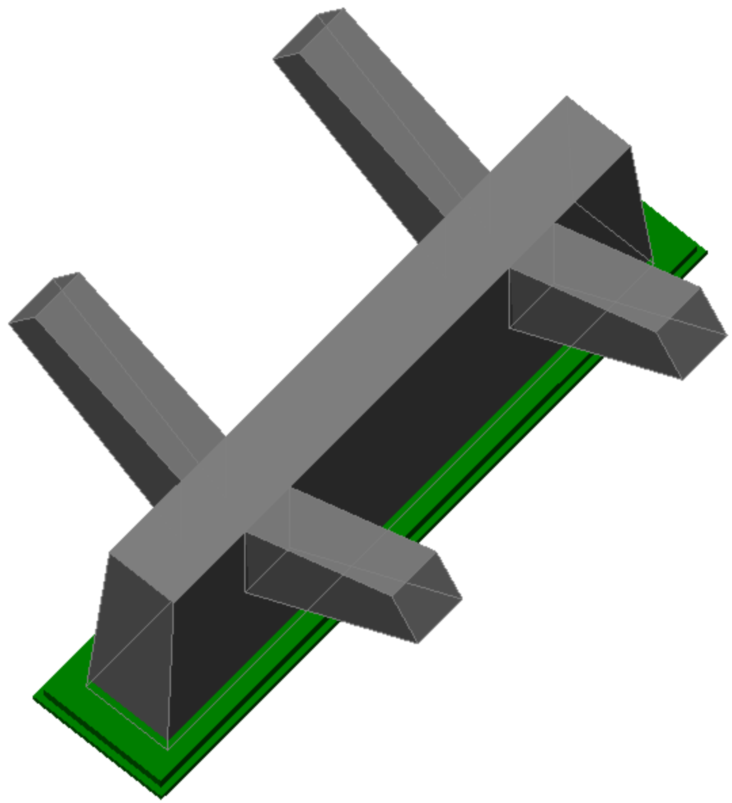


Support pier concrete weight

Pour Upper Pier and Angel Wings



Disassemble Walls, Slab to Remain

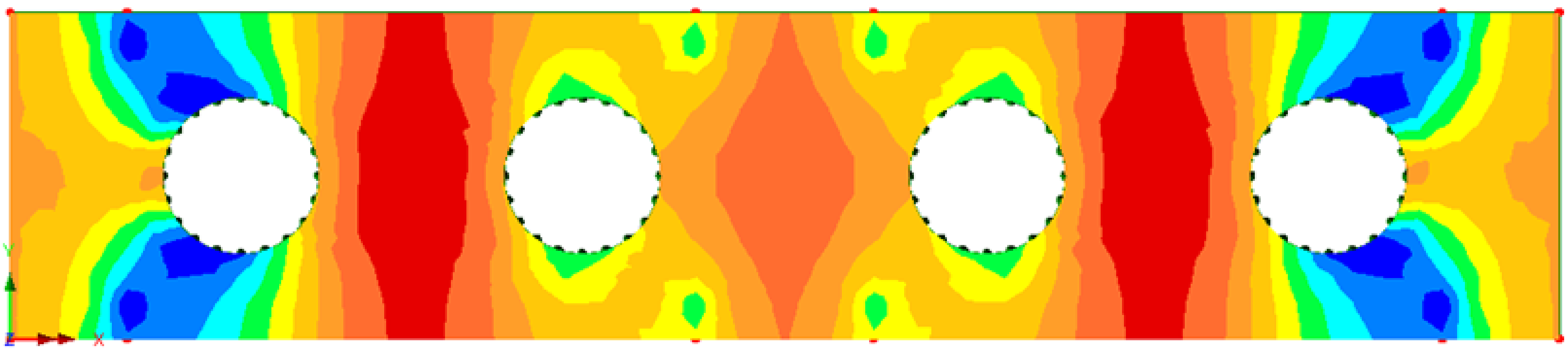


Analysis & Design

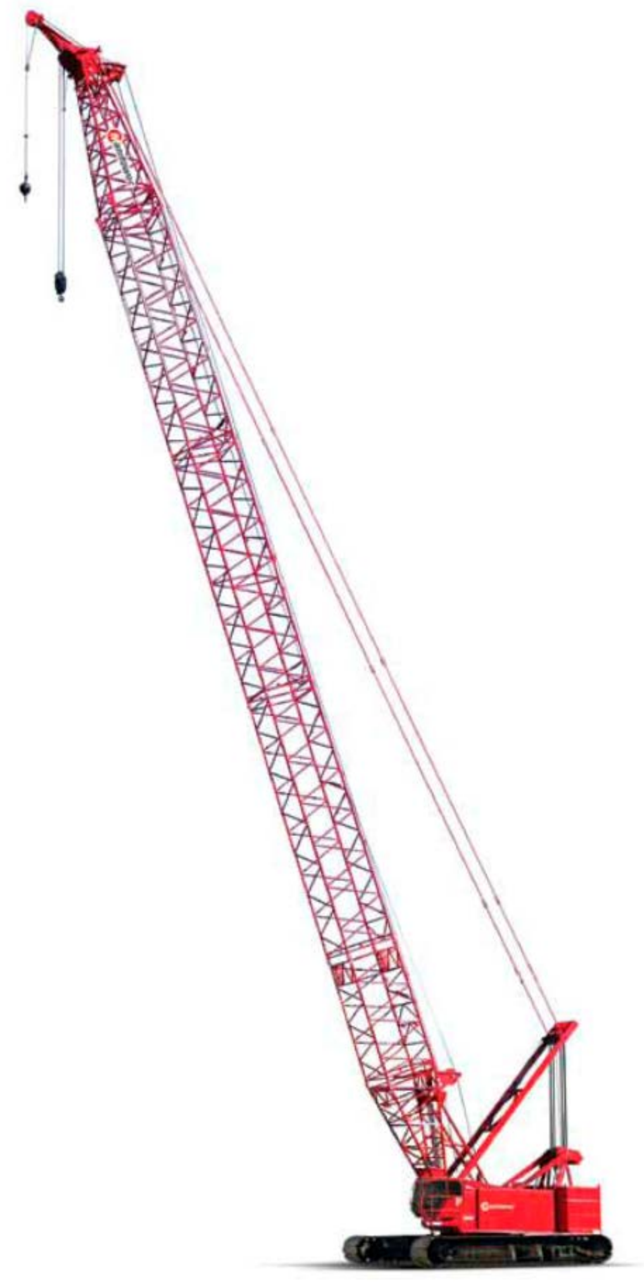
Analysis & Design Steps

- LUSAS 3D Finite Element Analysis Software
- Check loading for:
  - Oscillator drilling forces
  - Base slab pour
  - Jack-down distribution
  - Bouyant uplift
  - Pier concrete weight

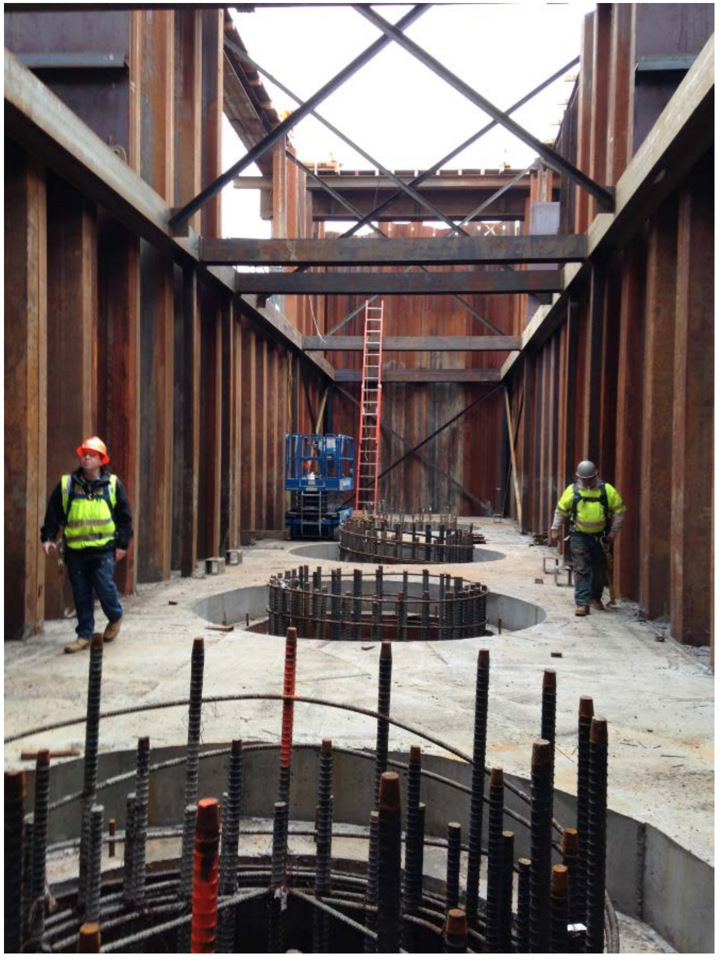
Voided Slab Design



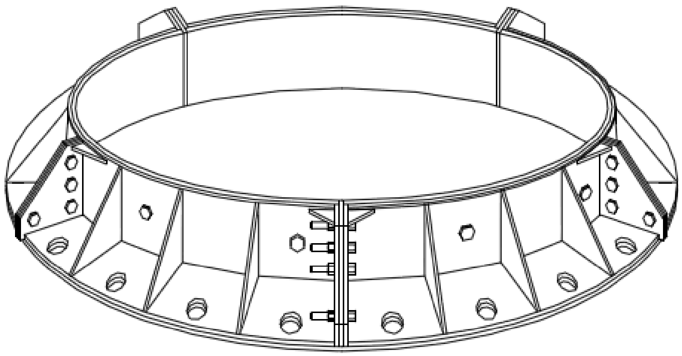
Construction Photos



Inside Box Prior to Jack-down



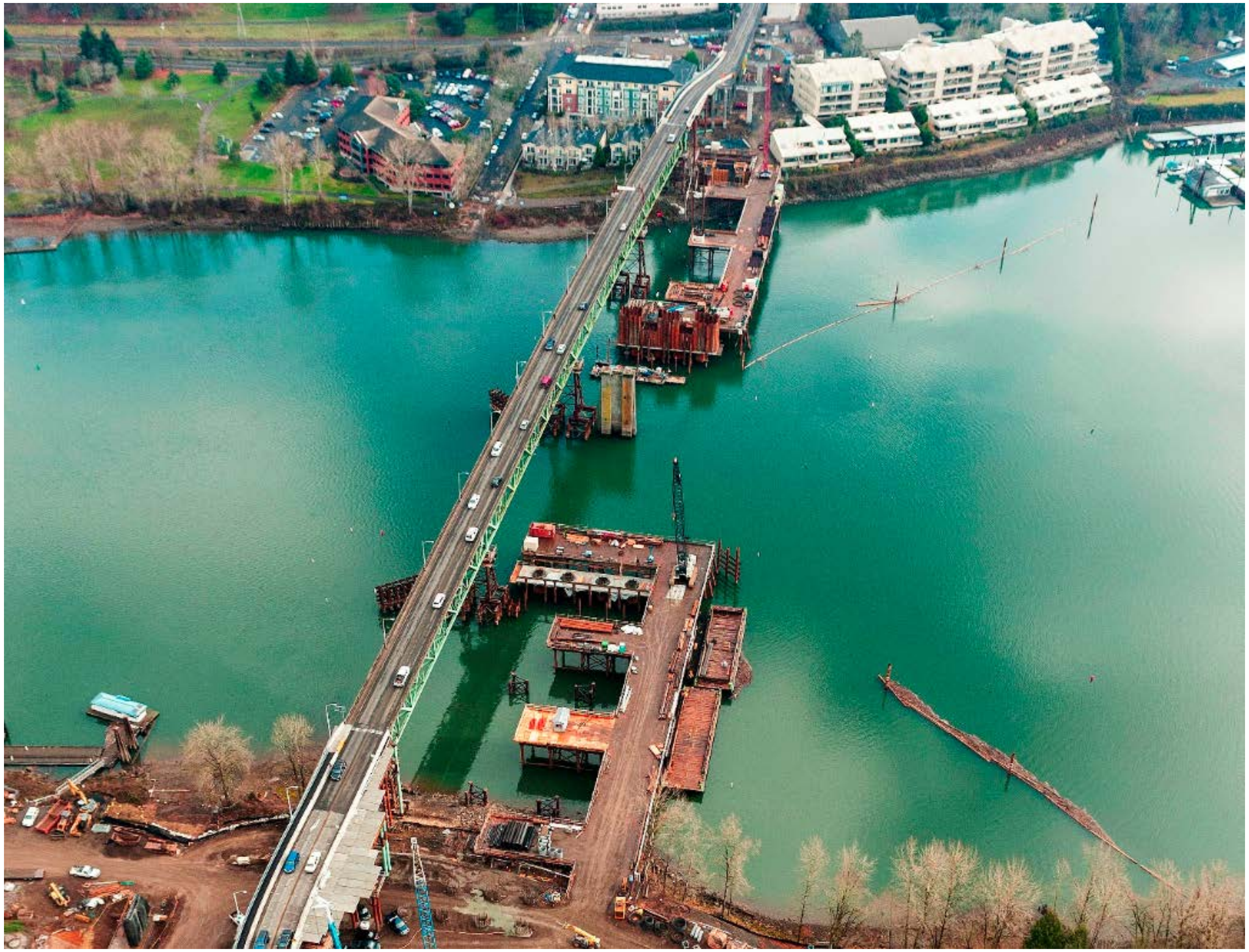
Tie-Down Collar



Design → Fabrication

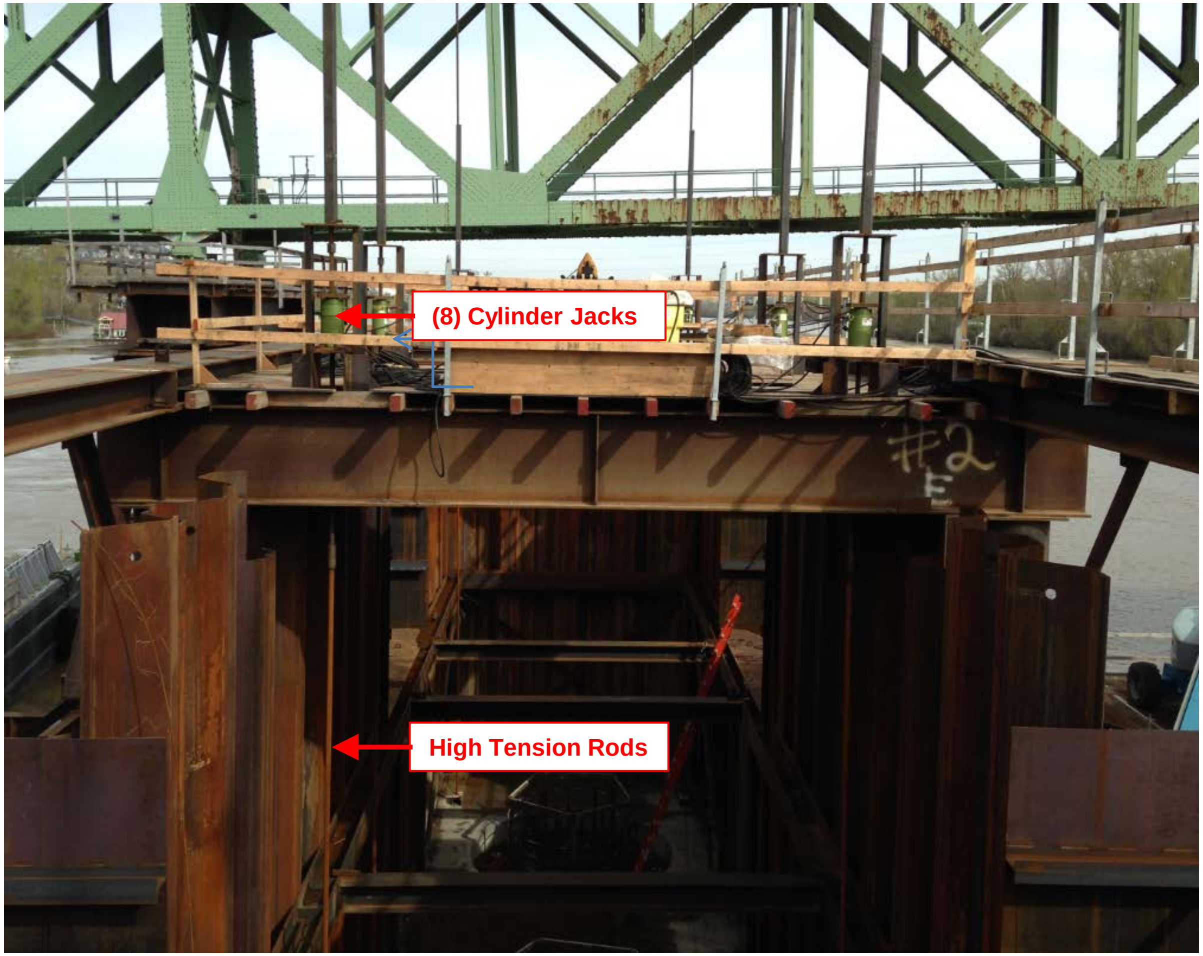
…or Flying Saucer

Aerial View

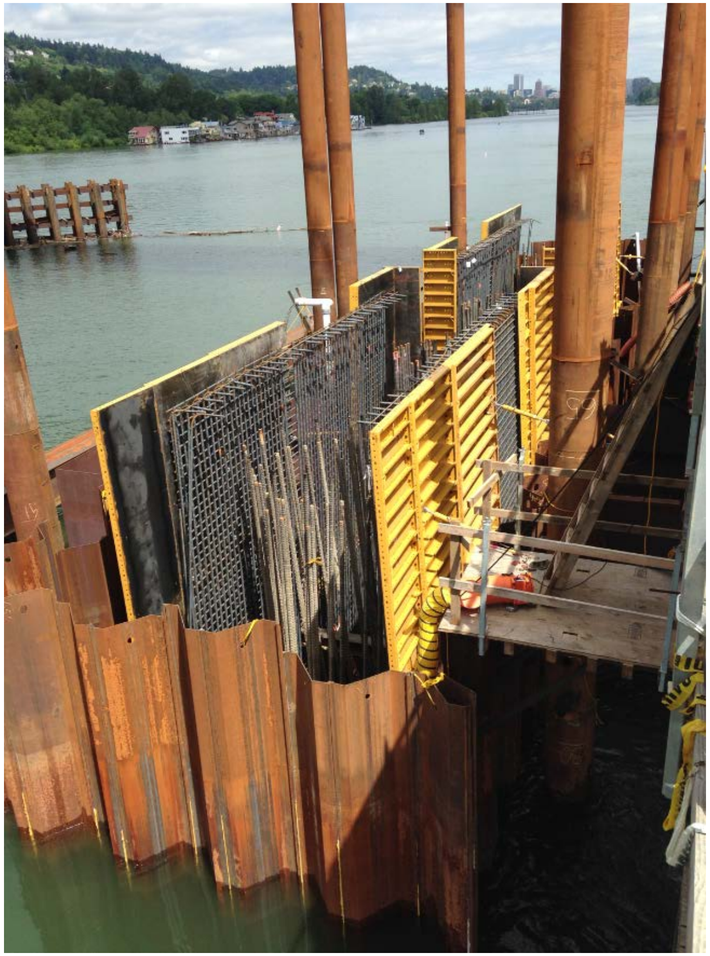


Elevated Position

Jack-down Frame



EFCO Pier Forms



High Water

Completed Pier

Time-Lapse Video

November 2013 – February 2014

Contractor Feedback

Construction Benefits

- Quantities saved:

Structure	Steel	Concrete	Dredging
Traditional Cofferdam	1,170 Tons	6,130 yd^3	13,100 yd^3
Perched Box Caisson	390 Tons	380 yd^3	0 yd^3
Savings	780 Tons	5,750 yd^3	13,100 yd^3

- Reduced environmental liability
- Easy access for materials

Additional Benefits

- Easier permitting with lower total pile count. Reused 3800LF temporary pile.
- No tremie concrete = no contaminated water. Dewater directly back into river.
- Construction schedule not limited to in-water work restrictions.

Challenges and Lessons Learned

- Synchronizing jacks to maintain slab tolerance during Jack-down was difficult.
- Creating a water-tight seal at the sheet to concrete interface was costly and time consuming.
- Joints at birds mouth forms to sheet pile are difficult to achieve water-tightness.

Suggestions for Improvements

- Negotiate larger allowable stay-in-place falsework
- Avoid birds mouth forms when possible
- Improve sealing methods prior to jack-down
- Improve control during jack-down
- Increase pumping rate during dewatering
- Modify tie-down collar to reduce underwater construction
- More robust pile for shaft drilling

Questions?