Sellwood Replacement Bridge

Perched Box Caisson Design & Construction

...a cofferdam alternative
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:

NOT ALLOWED
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:
NOT RECOMMENDED
Elevated Pier - Option 2C
Perched Box Caisson

Constructability Limitations
- Fabrication Intensive
- Requires “Birds Mouth” Forms

Conclusion:
SELECTED OPTION

Area ≤ 35ft²
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

1+1=2
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
...or Flying Saucer
Elevated Position
Jack-down Frame

(8) Cylinder Jacks

High Tension Rods
EFCO Pier Forms
High Water
Completed Pier
Time-Lapse Video

November 2013 – February 2014
Contractor Feedback
Construction Benefits

- Quantities saved:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Steel</th>
<th>Concrete</th>
<th>Dredging</th>
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</thead>
<tbody>
<tr>
<td>Traditional Cofferdam</td>
<td>1,170 Tons</td>
<td>6,130 yd³</td>
<td>13,100 yd³</td>
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<tr>
<td>Perched Box Caisson</td>
<td>390 Tons</td>
<td>380 yd³</td>
<td>0 yd³</td>
</tr>
<tr>
<td>Savings</td>
<td>780 Tons</td>
<td>5,750 yd³</td>
<td>13,100 yd³</td>
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</tbody>
</table>

- 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?