WSDOT’s Alaskan Way Viaduct Replacement Project: SR-99 Seattle Tunnel Precast Deck
August 22, 2019

Presenters:
- Mark Gaines, PE, WSDOT Bridge & Structures Engineer
- Tim Moore, PE, SE, WSDOT Mega Project Bridge Manager
- Jim Parkins, PE, Concrete Technology Corp
Building a new SR 99 Corridor

$3.2 B Replacement Program includes $1.4B Design-Build Tunnel
This is a **SAFETY** project

The viaduct and neighboring seawall are vulnerable to earthquakes
Meet Bertha, the SR 99 Tunnel Boring Machine

- 57’ – 4 ½” Overcut
- 6700 tons
- 10 bar pressure
- 88M lbs thrust
- 24ea by 750 hp drive motors
- 0-2 rpm
- 24 Mw operating
56’ Diameter Tunnel Design

- Electrical rooms
- Egress corridor
- Equipment rooms
- Utility corridor
- Pump station
- 56’ Outside Diameter
- Smoke extraction duct

Alaskan Way Viaduct Replacement Program
<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tbody>
<tr>
<td>Tunnel Boring Machine</td>
<td>Tunnel Boring, 1 yr</td>
<td>SB Portal Frame</td>
<td>Precast NB Deck</td>
<td>NB Deck</td>
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<tr>
<td>Repair, 2 years</td>
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<td></td>
<td>8 month Time Savings</td>
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<td>Mechanical, Electrical and</td>
<td>Cast-in-Place NB</td>
<td>Viaduct Demolition</td>
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<td>Plumbing Systems</td>
<td>Roadway Construction (Est)</td>
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<td>Tunnel open to drivers (Feb. 4)</td>
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Temporary Tunneling Elements

- Ventilation Duct
- Muck Conveyor
- Liner Panel Delivery Vehicle
The tunnel behind Tunnel Boring Machine, TBM, named Bertha, August 18, 2016
Begin Precast Installation

1. Build road and wall foundations
2. Build northbound roadway walls
3. Build southbound roadway (top deck)
4. Build southbound walls
5. End of tunneling: Build northbound roadway
6. Completed tunnel

BUILDING THE HIGHWAY inside the tunnel
BUILDING THE HIGHWAY
inside the tunnel
STP crews build the rebar cage for future roadway walls.

Interior roadway construction.

BUILDING THE HIGHWAY — inside the tunnel.
• Panel Length 29’-9 1/2”
• Panel Width 8’- 0”
• Panel Depth 14 1/2”
• Total # of Panels 1152 ea.
• f’c = 7.0 ksi
• Pre-Tensioned Transversely
• Post-Tensioned Longitudinally
• STP and HNTB Idea

Clear opening – 33’- 4” to deliver and rotate panel (3.5’ added clearance)
BUILDING THE HIGHWAY inside the tunnel

Northbound Lower Roadway Pre-stressed Post-Tensioned Slab with O’Lay
Typical Unit of 25 panels – Length is 201’ (47 Units)

Middle panel is anchored to corbels with five – 5/8” threaded rods per each bearing.

**PT Design Objective** – Connect slab girders together to produce 250 psi compression after all losses per AASHTO 5.14.4.3 and prohibit tension cracking in the top surface that can be reflected through the overlay.
SERVICE LIMIT STATE: MAX. LONG. POSITIVE MOMENT (ENVELOPE)

- LOAD FACTORS: 1.00 DW + 1.00 VEHICLE LL + 1.00 V POP
- UNIT: KIP-FT/FT

\[ \sim 17.65 \text{@ MAX.} \]
LIVE LOAD DEFLECTION CHECK

SEE ORIGINAL DESIGN PACKAGE FOR LOADINGS.

LL DEFORMATION = 0.362 in < \frac{2}{800} = 0.434 in

.: OK

FOR SR 99 TIS-NBRwy-Slab (Job No. 48055)
Made By: J. Wu Date: 3/12/2013
Checked By: _____ Date: _____
BackChecked By: _____ Date: _____
Corrected By: _____ Date: _____
Verified By: _____ Date: _____

CSIBridge v15.2.0 - File:TIS-3DModel-NBRoadway-v1.03 - Deformed Shape (Truck-LLDeflection) - Kip, in, F Units
Model Location: \(\text{ispw00v48056\_SAPData\_Tunnel\_Interior\_Structure\_3D\_Models\_NBRwy\_CSI\_Input}\)
PT Anchorage Slab

- Strut & Tie Model
- Bursting & Splitting Reinforcement within panel
Panel Width Determination
• Minimize total joints
• Maximum allowable width for plant casting
• Maximum weight for handling/rotation inside tunnel
• Maximum weight for standard flatbed truck (cost and avoid travel curfew)
• 8’ selected as optimized width
Longitudinal Shear Key between Panels
Match Cast vs. Standard
• Standard key provides more tolerance
• Standard key allows articulation along horizontal curve
• Match cast has faster field installation
• Match cast erecting sequence has little flexibility
• Match cast will increase plant fabrication cost significantly

Match-cast

Standard
Tunnel Orientation vs. Casting Bed Layout

Pre-Tension Strand

Post-Tension Duct

Casting Bed

Casting Bed
- 7 pcs. on 250’ casting bed typical
- 3 pcs. for slabs with PT anchor
UTILITY COORDINATION- Contract drawings specify 4 total types of panels
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Typical Unit of 25 panels – Length is 201’ (47 Units)

Middle panel is anchored to corbels with five – 5/8” threaded rods per each bearing.
UTILITY COORDINATION- Contract drawings specify 4 total types of panels

EMBEDDED CHANNEL SUPPORT AT BOTTOM. TYPE, SIZE, AND LOCATION SHALL BE COORDINATED WITH CONTRACTOR. SEE PLAN NOTE 8 BELOW AND DETAIL 2 ON SHEET ST611
UTILITY COORDINATION - 4 mark numbers turned into 304
Rules for Utility Coordination Developed

- Prestressing strands treated as immovable objects
- Raised strand c.g.
- Conventional rebar can be adjusted
- Standardize locations of inserts as much as possible
Why Mark Number Control is Important
Increased mark numbers increases costs for:
• Drafting and project management
• Yard stockpiling
• Shipping sequence
• Erection
Other Production Considerations

- Custom form sides for precision alignment of PT duct
Concrete Properties

• Release strength, $f'_{ci} = 5.6$ ksi, achieved in 10 hour cure for daily turnover
  • Type III cement
  • Low w/c ratio
  • Accelerated curing
• Release strength is a calculated value, not a ratio of service strength
• Self-consolidating concrete used
Production Summary

- 1,152 pieces total
- Cast seven pieces per day typical, 5 days a week
- Total duration of casting was 9 months
Quality Control

- CTC provided quality control;
  - Fresh concrete testing; slump flow, j-ring, unit weight, air content, temperature
  - Hardened concrete testing (compression cylinders)
  - Pre-pour inspection
  - Post-pour inspection
  - Documentation of non-conformances, re-work and completion of repair
- Raw material test reports from suppliers
- Aforementioned compiled into certificate of conformance packet
- Review and approved by STP
Global Tolerance Mitigation
• Three – 3’ long CIP closures provided at north end of tunnel to absorb accumulated tolerances for fabrication and erection

Lessons Learned
• Mark number control was acceptable, but could be improved by;
  • Utilize longer “track type” inserts
  • Utilize inserts with greater flexibility fore/aft, and lateral
  • Utilize suspension system with greater flexibility
• Tradeoffs of increased cost for more flexible MEP solutions vs. higher plant production costs for increased mark numbers

Manufacturer Perspective
• WSDOT and contractor engaged CTC early and often to optimize the precast slab option, which provided great returns upon execution for all parties
3” by 7’ long bearing consisting of two 1/8” Ultra High Molecular Weight, UHMW, Strip bonded to ¼” Neoprene Strip with thin layer of silicone grease between bearings.
Mono-strand ram with curved jack chair fits in dual anchorage blockouts.
PT Operation – 201’ Stressing Length
Deck Preparation by Shotblasting – Roughen and Clean
Dow Corning 902 RCS Silicone Sealant Joint
Lessons Learned

• Tyne top surface of panels during panel casting
• Evaluate super-elevation transition areas for bearing flatness
• Expansion joint polymer header
Questions?