Delivery of Accelerated Bridge Construction
WSDOT Workshop
Wednesday April 1st, 2015

New Development in Accelerated Bridge Design and Construction in WA

Washington State Department of Transportation
Bridge and Structures Office
Olympia Washington
Presentation Summary

1. ABC Projects
2. ABC Related Research Projects
3. New Wide Flange Deck Bulb Tee Girders with UHPC Closure
4. Accelerated Bridge Construction – Lateral Slide
5. Geosynthetic Reinforced Soils Integrated Bridge System GRS-IBS
6. Standardization of Precast Culverts
Summit -1: P2P Exchange - PBES
Prefabricated Bridge Elements & Systems
Accelerated Bridge Construction
November 13-16, 2012
Seattle, Washington

Summit -2: Every Day Count – GRS-IBS
November 29-30, 2012
Portland, Oregon
Challenges in the implementation of PBES/ABC

✓ Lack of Education, Training, and experience
✓ Concerns about durability and quality
✓ Lack of defined decision process for PBES/ABC
✓ PBES/ABC process is not integrated into practices
✓ Lack of perceived need for speed
✓ Lack of interest from the construction industry
Prefabricated Bridge Elements & Systems

- **Superstructures**
  - Deck Panels: Partial & Full-Depth
  - Prefabricated Beams: Optimized for ABC
  - Total Superstructure Systems:

- **Substructures**
  - Pier Caps, Columns, & Footings
  - Abutment Walls, Wing Walls, & Footings

- **Totally Prefabricated Bridges**
Example of ABC Related Bridge Projects in WA - Superstructure
Example of ABC Related Bridge Projects in WA - Substructure
ABC Research Projects in Washington State

- Design of Precast Concrete Piers for Rapid Bridge Construction in Seismic Regions
  University of Washington, August 2005

- Anchorage Of Large-diameter Reinforcing Bars Grouted Into Ducts
  University of Washington, November 2007

- Highways for LIFE Precast Bent System for High Seismic Regions
  BergerABAM and University of Washington, March 2013

- Reinforced Concrete Filled Tubes for use in Bridge Foundations
  University of Washington, June 2012
  Reinforced Concrete Filled Tubes for use in Bridge Foundations
  Phase 2: Shear capacity of CFT

- Seismic Performance Of Square Nickel-titanium Reinforced ECC Columns With Headed Couplers
  University of Nevada, Reno, July 2014

- Accelerated Bridge Construction (ABC) Decision Making and Economic Modeling Tool
  Oregon State University, December 2011
Participation in ABC Webinars

ABC Center at Florida International University - ABC-UTC

• October 2013 - Washington State’s Skagit River Bridge Emergency Slide - WSDOT
• September 2014 - SR167 Puyallup River historic bridge lateral slide – Jacobs-WSDOT

NHI Innovation Web Conference

• August 2011 - Precast Bent System for Use in High Seismic Regions – ABAM-UW-WSDOT
• August 2013 - Precast Bent System for Use in High Seismic Regions – ABAM-UW-WSDOT
ABC Folios and Tech Notes
NCHRP ABC Projects

- **NCHRP 12-102**: Recommended AASHTO Guide Specification for ABC Design and Construction
- **NCHRP 12-105**: Proposed AASHTO Seismic Specifications for ABC Column Connections
- **NCHRP 12-101**: Seismic Design of Bridge Columns with Improved Energy Dissipating Mechanisms
- **NCHRP 12-88**: Synthesis on System Performance of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions
- Others
Beam Elements

Prefabricated Deck Beam Elements include:

- **Deck Bulb Tee Beams**
  - Precast Deck Elements
  - Precast Box Beams
  - Precast Slabs
New Wide Flange Deck Girders

Efficiency of DBT Girders (4 ft wide Top Flange)

\[ \rho = \frac{r^2}{y_b y_t} \]
\[ r = \sqrt{\frac{I}{A}} \]

Girder Depth (in.)

Span Range of standard wide flange DBT concrete:

- Thin deck span up to 225 ft (250 ft LW Girders)
- Deck girders span up to 195 ft (230 ft LW Girders).

Washington State Department of Transportation
Efficiency Of Prestressed Girders

- **New Wide Flange Girders**
- **Old Girder Series**
- **AASHTO/Girders**
- **AASHTO/PCI**

EFFICIENCY OF PRESTRESSED GIRDERS
Superstructure Replacement, Span = 145 ft

Span 8 ~ 48 feet Above Tracks

Existing: 15 - W74G Girder
Replacement: 7 - WF74G Girder
## December 2011 Concrete Products Article by Don Marsh

### Record-Length Prestressed Concrete Girder Bridges

#### 2000-2011

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Length</th>
<th>Year</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware Trail of Ohio River</td>
<td>107 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>I-295 over Mo-Mich at Kennett</td>
<td>636 ft</td>
<td>2007</td>
<td>Concrete Technology Corp</td>
</tr>
<tr>
<td>Mo-Tah</td>
<td>202 ft</td>
<td>2001</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Fort McPherson Rd</td>
<td>323 ft</td>
<td>2001</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Brownsville, TX</td>
<td>288 ft</td>
<td>2001</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Chantilly, VA</td>
<td>216 ft</td>
<td>2000</td>
<td>Concrete Technology Corp</td>
</tr>
<tr>
<td>Iowa City Region</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Philadelphia, PA</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>New York City</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>288 ft</td>
<td>2000</td>
<td>Carver Bridge Structures</td>
</tr>
</tbody>
</table>

#### 1959-1999

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Length</th>
<th>Year</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rockefeller Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzl Products</td>
</tr>
<tr>
<td>County Line Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Independence Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Missouri Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Santa Fe Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Zephyr Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Rainbow Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Golden Gate Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
<tr>
<td>Dan River Bridge</td>
<td>360 ft</td>
<td>1962</td>
<td>Schlitzel Products</td>
</tr>
</tbody>
</table>

---

### Take It to the Limit

Value engineering, design-build methods, steer states’ record-length girder specs.
Wide Flange Deck Bulb Tee Girders

- **Girder Types:**
  - Type 1: CIP Slab = 5” min. for WSDOT Projects
  - Type 2: CIP concrete Overlay = 1 ½” for Low ADT

- **Concrete Types:** Normal weight, and LW

- **Top flange width:** 5.0 ft, 6.0 ft, 7.0 ft, 8.0 ft

- **Closure Types:**
  - CIP UHPC connection with lap spliced bars
  - Welded ties and grouted key connection for Low ADT Roads/Others
Deck Girders: Skagit River Bridge Replacement - ABC and A+B+C

Connection of Deck Beam Elements
Research Pays off: New NCHRP Publication

- NCHRP 18-15 High-Performance/High-Strength Lightweight Concrete for Bridge Girders and Decks
- FHWA HRDI-40 - Lightweight Concrete for Bridge Girders: Contact: Ben Graybeal
- FHWA-HRT-13-060 - Ultra-High Performance Concrete for Bridges, Ben Graybeal
- Nchrp 12-69 - Guidelines for Design and Construction Of Decked Precast, Prestressed Concrete Girders
- NCHRP 173 - Cast-in-Place Concrete Connections for Precast Deck Systems
Connection of Deck Beam Elements

SR 31 over Canandaigua Outlet Lyons, New York Ultra-High Performance Concrete (UHPC)
Past Performance of Deck Girder Bridges
2015 WSDOT Research Project

Use of UHPC For Decked Girder Connections Between Adjacent Units

Research Objective: WSU and UW

- Develop UHPC mix design
- Performance of longitudinal joints using UHPC
- Distribution of live load between adjacent units
- Continuity for live load
- Lap splice length using UHPC
Summit -2: Every Day Count – GRS-IBS
Geosynthetic Reinforced Soil Integrated Bridge System

- Eliminates approach slab
- Reduced construction time (complete in 10 days)
- 25 - 60 % less cost depending on standard of construction
- Flexible design – easily modified for unforeseen site conditions
- Built with common equipment and materials
Geosynthetic Reinforced Soil-Integrated Bridge Systems (GRS-IBS)

3 Main Components of a GRS-IBS:

1. Reinforced Soil Foundation
2. GRS Abutment
3. GRS Approach

The Choice of Geotextile or Geogrid

- Geotextiles:
  - Non-woven geotextiles are porous and have high in-plane drainage capacity, but poor tensile capacity.

- Geogrids:
  - Provides high tensile strength, but poor in-plane drainage capacity.

*Depends on the type of backfill soil to be used*
Geosynthetic Integrated Bridge System
WSDOT Fish Passage Culverts Replacement

- WSDOT to correct 825 fish barriers by 2030.
- 30 to 40 culverts each year between 2015 – 2030.
- $310 million per biennium ($2.4+ billion Total).

Fish Passage Structures are Suitable For:
- ABC – Lateral Slide
- Deck Girders
- GRS-IBS
- Precast Culverts
Scope of Work: Fish Passage Projects

Bridges and Culverts

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fish Passages</td>
<td>825</td>
</tr>
<tr>
<td>% Bridge</td>
<td>40%</td>
</tr>
<tr>
<td>Total Bridge</td>
<td>330</td>
</tr>
<tr>
<td>Remaining Culverts and Stream Realignment</td>
<td>495</td>
</tr>
<tr>
<td>Culverts with span over 20 ft</td>
<td>50%</td>
</tr>
<tr>
<td>Total Culverts</td>
<td>248</td>
</tr>
<tr>
<td>Added to WSDOT Bridge Inventory by No of Structures</td>
<td>578</td>
</tr>
<tr>
<td>Added to WSDOT Bridge Inventory by %</td>
<td>16%</td>
</tr>
</tbody>
</table>
Precast Concrete Culvert Standardization

Fill 2 to 50 ft

Precast Arch = 4 to 8 ft Rise

CIP Stem Wall

CIP Foundation (Spread Footing, Pile or Shell)

Preliminary Design Aid: Span, Rise, Fill, Precast Arch Dimensions, etc.

<table>
<thead>
<tr>
<th>SPAN (S)</th>
<th>50'-0&quot;</th>
<th>51'-0&quot;</th>
<th>52'-0&quot;</th>
<th>53'-0&quot;</th>
<th>54'-0&quot;</th>
<th>55'-0&quot;</th>
<th>56'-0&quot;</th>
<th>57'-0&quot;</th>
<th>58'-0&quot;</th>
<th>59'-0&quot;</th>
<th>60'-0&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL HEIGHT (H), ft</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
<td>8-0</td>
</tr>
<tr>
<td>ROOF RISE (R), ft</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
<td>2-0</td>
</tr>
<tr>
<td>ROOF THICKNESS T1, in.</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
<td>11&quot;</td>
</tr>
<tr>
<td>WALL THICKNESS W1, ft</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
<td>1'-1&quot;</td>
</tr>
<tr>
<td>CORNER RADIUS, ft</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
<td>2'</td>
</tr>
</tbody>
</table>
Standard Precast Concrete Culvert

- Design Criteria & Design Specifications
- Preliminary Design Aids
- Span Capability Charts
- Design Tools and Software
- Bridge Design Manual & Standard Details
- Standard Drawings for Arch Structures
- Improved Joint Details between Segments
- Complete PS&E Package and Contract Plans
Accelerated Bridge Construction Resources (ABC)

Reports
- WSDOT ABC Strategic Plan (pdf, 161kb)
- FHWA Seismic ABC Workshop Report (pdf, 998kb)
- ABC Seismic Connections - TRB Research Proposal (pdf, 5.2mb)
- Design of Precast Concrete Piers for Rapid Bridge Construction in Seismic Regions (pdf, 2.78mb)
- A Precast Concrete Bridge Bent Designed to Re-center after an Earthquake (pdf, 2.82mb)
- Rapidly Constructible Large-Bar Precast Bridge-Bent Seismic Connection (pdf, 8.4mb)
- Anchorage of Large-Diameter Reinforcing Bars Grouted into Ducts (pdf, 1.9mb)
- Fully Precast Bridge Bents for Use in Seismic Regions (pdf, 356kb)

Presentations
- Presentations from WSDOT ABC Workshop (September 30, 2008) (500mb)
- Presentations from WSDOT-CalTrans TRB 2009 Seismic ABC Collaboration (612mb)
- Lewis and Clark Bridge Deck Replacement (pdf, 11mb)
- Rapid Replacement of the Hood Canal Bridge Approach Spans (pdf, 9.07mb)
- ABC Pooled Fund Meeting (pdf, 960kb)
- HFL Testing Briefing (pdf, 5.3mb)
- A precast Concrete Bridge Bent for Seismic Regions: Achieving both Performance and Constructability (pdf, 9.6mb)
- Unbonded pre-stressed connections (pdf, 1.1mb)
- Concrete Filled Steel Tubes for Bridge Foundations

Links
- Highways for Life

✓ ABC Website – Rick Brice
✓ ABC BDM Chapter – Patrick Gallagher
✓ Folios and Tech Memos – Paul Kinderman
✓ New Deck Girders - Rick Brice –Scott Sargent – Brian Aldrich
✓ Culverts – Lou Tran – Mark Szewcik

Thank You!