Developing Precast Guidelines for Accelerated Bridge Construction

Program Outline

- Background on PCI Northeast Bridge Technical Committee
- Development of Precast Substructure Guidelines
- Development of the NEXT Beam
- UHPC
- Deck Panels

PCINE Bridge Technical Committee

- PCINE Technical Committee was established in 1990
- Members included State Department of Transportations Engineers from New England and New York, Consultants and Precastors
- Focus is on Updating and Developing Regional Standards for ABC Bridge Construction since 2004

Reports Developed by the Technical Committee

- NEBT Preliminary Design Charts
- NEBT Post-Tensioned Design Guidelines
- High Performance Concrete Specification
- Prestressed Concrete Girder Continuity Connection
- Precast Deck Panel Guidelines
- Full Depth Precast Concrete Deck Slabs Guidelines
- Bridge Member Repair Guidelines
- Accelerated Bridge Construction Guidelines
- NEXT Beam Details and Design Charts

In 1995 - First Prestressed Girder Developed - NEBT

Section was adopted by New England and New York
Also Adopted by New Brunswick and Quebec
Reports are available at www.pcine.org

Cross Street Bridge, Middlebury VT
- Harry H Edwards for Industry Advancement Award
- Fox Bridges150 ft and Longer Award
- Longest Single Span Splice Girder Bridge in the US
- 240 Main Span

I-91 Bridges in Windsor, VT

Longest Single Piece Bulb Tee Shipped – 157’

PCINE Bridge Technical Committee Focused its work on Accelerated Bridge Construction starting in 2004.

Timeline:
• 2004 – Developed an Accelerated Bridge Guidelines Report
  Completed 2006
• 2006 – Begin Development of the NEXT “F” Beam
  Completed 2008 – First Bridge Built in 2010
• 2008 – Begin Development of NEXT “D” Beam
  Complete 2010 – First Bridge Built in 2011
• 2011 – 2nd Ed. Full Thickness Deck Panel Report Updated
• 2012 – Developed Prefabricated Bridge Elements & Systems Guide Details – Completed and Posted June 2012
• 2012 – Develop Guidelines for Precast Approach Slabs – Completed and Posted November 2012

Current Work:
• 2012 Update the Accelerated Bridge Guideline Report
• Develop Standard Details for Deck Bulb Tees
• Development of NEXT E

Accelerated Bridge Guidelines Posted 2006

In 2004 the PCINE Committee began developing ABC Guidelines

“Guidelines for Accelerated Bridge Construction using Precast/Prestressed Concrete Components”

• Section 1: Application Overview
• Section 2: General Requirements
• Section 3: Precast Components
• Section 4: Joints
• Section 5: Grouting
• Section 6: Seismic
• Section 7: Fabrication & Construction
What are Prefabricated Bridge Elements & Systems

PBES
- Superstructures
  - Deck Panels: Partial & Full-Depth
  - Prefabricated Beams: Optimized for ABC, Optimized Shape, or Best Selected Section
  - Total Superstructure Systems:
    - Composite Units, Truss Spans
- Substructures
  - Pier Caps, Columns, & Footings
  - Abutment Walls, Wing Walls, & Footings
  - Total Substructure Systems
- Totally Prefabricated Bridges

PBES Concrete Elements

Superstructure:
- Adjacent Slab and Box Beams without CIP Deck
  - With or Without Overlay;
- Deck Bulb Tee Beams Without CIP Deck
  - With or Without Overlay;
- NEXT Beams
- Precast Segmental Box Segments
- Precast Arch Spans

Chapter 5

Typical Prefabricated Elements

Latest FHWA ABC Manual

Accelerated Bridge Construction Experience in Design, Fabrication and Erection of Prefabricated Bridge Elements and Systems

Published in November 2011
Available On-Line
Free Download


Appendices

Design Examples and Guidance
- Full depth precast deck panels
- Precast Concrete Piers & Abutments
- Erection and Lifting calculations for deck panels

Sample Construction Specifications
- UDOT – Precast Substructure Elements
- UDOT – Precast Concrete Deck Panels
PCI Northeast Guide Details posted 2012

- Based on experience in Utah and the NE region

Precast Piers

Typical Connections

Integral Abutments

- Corrugated Void Pockets

Cantilever Abutments
Cantilever Abutments

Pile Supported Footings

Pile supported footings
- Use corrugated pipe forms
- Used for integral abutment stems also

Tolerance Details

Objective
- Develop standardized approaches to designing, constructing, and reusing (including future widening) complete bridge systems.
- It addresses rapid renewal needs and efficiently integrates modern construction equipment.

SHRP2 Research Project

Transportation Research Board Project
SHRP 2 - Innovative Bridge Designs for Rapid Renewal
ABC Toolkit

ABC Toolkit
- Standard Plans for ABC Modular Systems
  - General Notes (Designer Notes)
  - Abutments (including Approach Slabs)
  - Piers
  - Steel Girder Superstructure
  - Concrete Girder Superstructure
- Erection Concepts for Modular Construction
- LRFD Designs (Mathcad)
- Contracting Language
- ABC Sample Design Calculations

www.trb.org/main/blurbs/168046.aspx
Development of the NEXT Beam

- Started in 2006 – Completed in 2008
- Accommodation of Utilities
- Reduce Fabrication and Installation Cost
- Works very well for Accelerated Construction.

Depth 24” – 36” in 4” increments
Typical Span Range 50 – 85’
Width will vary 8’-0” – 12’-0”

NEXT Beam Combinations

NEXT Beam
Preliminary Design Charts
6000 psi
8000 psi
10000 psi

Beam Depth
24 - 36"
Beam Width 8'-0" - 12'-0"
Preliminary Beam Design Charts

**DESIGN PARAMETERS**
1. Two lane 4 beam bridge section
2. 18 inch wide concrete girts with steel rail
3. 8 inch thick RC deck: fc = 4000 psi
4. 3 inch thick bituminous concrete overlay
5. Beam fc = 10000 psi
6. Beam = 6000 psi
7. Deflection up to 25% of span
8. AASHTO LRFD design with allowance for fatigue stresses for extreme exposure
9. Straight strand only
10. No utility loads
11. Design for tensile beam
12. Live load distribution factor based on composite deck stringer bridge, AASHTO cross section Type K

Load Charts available on PCI National Website - www.pci.org

The NEXT Beam

NEXT Beam Production

NEXT Beam Time Lapse Production

Additional Guidance on website www.pcine.org

- FAQ
- Design Assumptions

PCI BRIDGE DESIGN MANUAL

PCI
**York Maine Project**

Route 103 over York River York, ME
7 Span Structure - 510 Ft Long
Completed Ahead of Schedule November 2010
4" Additional Navigational Clearance

**York Maine Route 103 Project**

Development of the NEXT Deck “D” beam

- Full Thickness Slab.
- Details, section properties and connections.

Development of the NEXT Deck “D” beam

- Preliminary Load Charts for Normal & Light Weight Concrete

**Case Study - Sibley Pond Bridge – Canaan-Pittsfield, ME**

First NEXT “D”

Design-Build Project
Opened November 21, 2011
10-1/2 months ahead schedule
The bridge was designed and completed in 15 months. Designed for 100 year Service Life.

Credits – Parsons Brinckerhoff
**Case Study - Sibley Pond Bridge – Canaan-Pittsfield, ME**

- **Type of Bridge:** Highway Bridge – Stream/Pond Crossing
- **Structure & Geometry:**
  - 10 spans - two 5 span continuous units and a single expansion at center
  - Spans Designed for continuous for LL and SDL
  - Span Length - 79'-0" With Overall Bridge Length - 790'-0"
  - Overall Width - 36'-0" curb to curb
  - No. of Traffic Lanes - 2
  - Alignment/Skew - Tangent /0 skew
  - Longitudinal Grade ± 1.0% with crown at center of bridge

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**Design Considerations**

**Superstructure:**
- Beams - 8000 psi SCC mix with (DCI)
- MMFX rebar specified in exposed bridge curbs & rail barriers
- Deck protection: Deck waterproofing with asphalt overlay.
- One expansion joint at high point, with semi-integral abutments.

**Substructure:**
- Concrete filled steel pipe piles - shop applied fusion bonded epoxy coating system, extending from the top of the pile to 10 feet (3 meters) below the mud line

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**Sibley Pond Bridge – Canaan-Pittsfield, ME**

- Custom Gantry Crane
  - Gantry lifted the beams from trailers on the old bridge.
  - Rolled sideways across the new piers.
  - Less costly and quicker than 2 crane pick.
  - 4 Beams Erected in an 8 hour shift
  - Turnaround time of 2 days/span

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**Continuity Connection**

Live Load negative moment continuity over the piers. Mechanical Couplers were detailed to field splice the splice bars between adjacent beams.

- Couplers for (-) Moment continuity at intermediate diaphragms
Hurricane Irene

Hurricane Irene Storm Damage Bridge Replacements. There will be additional projects this year using precast.

Examples of Projects:
- Holiday Farm Road – Bridgewater, VT
- Water Andric Road; Dansville, VT
- Jim Earl Bridge; Bridgewater, VT
- Bracket Brook; Carrabassett, ME
- North Branch; Carrabassett, ME
- Richards Road Bridge, Grafton, VT
- Taylor Brook; Grafton, VT
- GMRC; Cavendish, VT
- Green MT. RR; Clarendon; VT
- Titus Rd Bridge; Moriah, NY
- East Lake Rd; Ludlow, VT

Vermont Accelerated Bridge

NEXT Beams

Approach Slabs Complete

Bridge 8 Finished

MassPort Logan Airport Runway Extension, Boston, MA
Beam Cost Considerations

<table>
<thead>
<tr>
<th></th>
<th>Box Beam</th>
<th>Next Beam</th>
<th>Conclusion</th>
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<tr>
<td>Fabrication</td>
<td>Multi-stage pour Draping</td>
<td>Simple Pour Straight Strand</td>
<td>Next Beam should have significantly lower fabrication cost per SF</td>
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<td>Shipping</td>
<td>One beam per truck (3'-4')</td>
<td>One beam per truck (8'-12')</td>
<td>Next Beam reduces the number of trucks (½ to ¼)</td>
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<td>Cranes</td>
<td>Lighter picks</td>
<td>Heavier picks</td>
<td>Shorter erection time</td>
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<td>Installation</td>
<td>Requires Transverse PT and grouting</td>
<td>Set it an move on</td>
<td>Much easier installation, no special grouts, no post-tensioning</td>
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Research Objectives

- Determine live load distribution factors (LLDF)
  - Estimate LLDFs using AASHTO equations (different S)
  - Compare Estimates with Finite Element Models
  - Evaluate estimated LLDFs with live-load testing of prototype bridge (Brimfield, MA)

- Monitor long-term performance of integral abutment NEXT beam bridge (3 years)

Update on Project Activities

- Parametric study of LLDFs complete
- Construction completed in Spring 2012
- Load test conducted on 24 May 2012
- Draft Report under review
- Long-term monitoring ongoing (3 years)
  - Readings every 2 hours since 24 May 2012
### TIMELINE NEXT Beam Developed in 2008

- **2009**: First NEXT Beam Cast
- **2010**: First NEXT Beam Developed
- **2011**: First NEXT D Bridges are Built in Maine & Vermont
- **2011-12**: Logan Airport uses NEXT Beams for Runway Extension and new Airport Viaduct
- **2012**: Several Projects already awarded; NY will build First Lateral Slide
- **2013**: First NEXT F Bridges Built in York, ME and Kittery, ME
- **2013**: First Curved Flange Project

### NEXT Beam Acceptance

- **States with NEXT Beam Built:**
  - MassDOT; Vermont AOT; MaineDOT, RIDOT, NJDOT; NYSDOT, DEDOT, NHDOT
- **States with NEXT Beam in Design/Construction:**
  - CTDOT; Pennsylvania DOT
- **States considering the use of the NEXT Beam:**
  - Virginia; North Carolina; South Carolina and Georgia

### Industry Capabilities

**NEXT Beam Suppliers**

- Blakeslee Prestress; Branford, CT
- J.P. Carrara & Sons; Middlebury, VT
- Oldcastle Precast; S. Bethlehem, NY
- Dailey Precast; Shaftsbury, VT
- Jersey Precast; Hamilton Township, NJ
- Coastal Precast; Chesapeake, VA
- High Concrete; Denver PA
South Maple Street; Enfield, CT

New York’s First Deck Bulb Tee Project

- 85'-0" (25.91 m) SPAN
- 42'-9" (13.03 m) WIDE
- 15 DEGREE SKEW
- 3'-5" (1.04 m) DEEP DBT
- 5'-4" (1.63 m) DBT SPACING

NY’s First Deck Bulb Tee Project

NY’s First Deck Bulb Tee Project

NY’s First Deck Bulb Tee Project
NY’s First Deck Bulb Tee Project

Testing began in May 2009
Test Plan:
- Cyclic testing below static cracking for 2M+ cycles
- Cyclic testing above static cracking for 5M+ cycles
- Static loading to flexural failure
- Surface is ponded with water during dynamic testing.

Ultra-High Performance Concrete
Connections Between Precast Bridge Deck Elements

UHPC Closure Pour – Cyclic Testing

Panel G1/G2 – After 5.8 Million Cycles to 21.3 kips

MADOT First Deck Bulb Tee Project

Eight – 1220 mm NEBT 5’ wide 95’ long Deck Bulb Tees 8000 psi Concrete – UHPC Joint

Easthampton, MA
MADOT First Deck Bulb Tee Project

Eight – 1220 mm NEBT 5’ wide 95’ long Deck Bulb Tees 8000 psi Concrete – UHPC Joint

Deck Bulb Tee Standards under development

UHPC Projects

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<th>UHPC Projects</th>
<th>Deck Bulb Tees</th>
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Full Depth Precast Deck Slabs Guidelines

Typical Framing Plan
Typical Piece Plan

Precast Deck Panels FAQ’s at www.pcine.org

Full Depth Precast Concrete Projects
Sanbornton, NH Precast Deck Panels

NE & NY Producers

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<th>Beams</th>
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Educational Programs

Precast/Prestressed Concrete Bridge Design Seminar
November 5, 2013 (8:00 am - 4:00pm)
Location: VTrans Training Center
1716 Route 302
Berlin, VT 05633
Speakers:
Roy L. Eriksson, PE - Eriksson Technologies, Tampa, FL
Register at www.pcine.org
Resources
Precast Prestressed Concrete Institute www.pci.org

Thank-You for your Attention
Questions?
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