WSDOT 2015 ABC Workshop
Bridge & Structures Office

7345 Linderson Way SW Tumwater WA
Room 1028

Wednesday April 1st, 2015
7:30am - 4:30pm

Precast Industry
Consulting Engineers
Construction Industry

Academia & Research
FHWA
WSDOT

Explore ABC

Presentations
Panel Discussion
**WSDOT 2015 ABC Workshop**

**Bridge and Structures Office**

**AGENDA**

**Moderator: John Stanton, University of Washington**

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**Morning**

**Registration**

Time: 7:30 – 8:00 am

**Welcome and Introductions:**

Time: 8:00 – 8:15 am

Tom Baker, WSDOT
Debbie Lehman, FHWA

**Session 1 Presentations: Big Picture for ABC**

Time: 8:15 – 10:00 am

- Ben Beerman, FHWA — “ABC National Perspective”
- Mary Lou Ralls, Ralls Newman, LLC — “Resources Available through the ABC University Transportation Center”
- Chuck Prussack, Old Castle — “Overview of ABC Projects in the PNW”

**Morning Break**

Time: 10:00 – 10:15

**Session 2 Presentations: Research & Development**

Time: 10:15 – 12:00

- John Stanton, University of Washington — “A Bridge Bent System Designed for Rapid Construction and Superior Seismic Performance”
- Atorod Azizinamini, Florida International University — “ABC-UTC Research Activities for Development of Steel Bridge Systems for Seismic Areas”
- Saiid Saiidi, University of Nevada at Reno — “Novel Materials and Concepts for ABC in Moderate and High Seismic Zones”
- George Ghusn, Structural Component Systems — “Rapid Column Systems Overview and Design Guide”
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Moderator: John Stanton, University of Washington

Lunch & Presentation:
Patrick Gallagher, WSDOT Bridge Design — “Update on WSDOT ABC Chapter for the Bridge Design Manual”

Afternoon Presentations: Case Studies
Time: 1:00–2:45 pm

• Bala Sivakumar, HNTB — “Using the SHRP2 ABC Toolkit”
• Dusan Radojevic, Buckland & Taylor — “Accelerated Deck Replacement for the MacDonald Bridge”
• Kevin Dusenberry, Jacobs — “Lateral Slide of Historic Bridge in Washington State”
• Greg Banks, BergerABAM — “Washington Highways for LIFE project and Recent Applications”

Afternoon Break
Time: 2:45–3:00

Panel Discussion — Viewpoints for Implementing ABC:
Moderators: Lee Marsh and Mark Gaines
Time: 3:00 – 4:20 pm

• Steve Seguirant — Precast Concrete Industry, CTC
• Saïd Saiidi — Research, UNR
• Mary Lou Ralls — National ABC, Ralls Newman
• Geoff Swett — Owner, WSDOT
• Jim Guarre — Design, BergerABAM
• Charlie DeGaparis — Contractor, Atkinson

Next Steps and Closing Remarks:
Time: 4:20 pm

Tom Baker, WSDOT

Adjourn
Time: 4:30 pm
ABSTRACTS

Session 1 Presentations

1-1 Benjamin Beerman, P.E. Senior Structural Engineer, FHWA, Benjamin.Beerman@dot.gov

Title: ABC National Perspective

Abstract: None

1-2 Mary Lou Ralls, P.E. Director, Technology Transfer, ABC-UTC, Principal, Ralls Newman, LLC., ralls-newman@sbcglobal.net

Title: Resources Available through the ABC University Transportation Center

Description: As accelerated bridge construction becomes common practice among the states, more and more resources are becoming available to help bridge owners implement successful ABC projects. The ABC University Transportation Center (ABC-UTC) is a repository to help get the word out about these many resources. The ABC-UTC is also a research engine to help address ABC technology gaps. This presentation describes resources available through the ABC-UTC and provides an overview of the status of current ABC-UTC research.

1-3 Chuck Prussack, P.E., Oldcastle Precast, chuck.prussack@oldcastle.com

Title: Overview of ABC Projects in the PNW

Description: Oldcastle Precast (formerly Central Pre-Mix Prestress) in Spokane, WA has been involved in several interesting Accelerated Bridge Construction (ABC) projects in the last few years. Perhaps due to their geographic location in Spokane, WA, they have done ABC projects for the States of Idaho, Montana, Washington, the FHWA, and the USFS. All these agencies used different techniques to accelerate the process with precast concrete. The presentation will show pictures and narrative of these projects, along with "lessons learned."

1-4 Bijan Khaleghi, WSDOT, Bijan.Khaleghi@wsdot.wa.gov

Title: New Development in Accelerated Bridge and Culvert Construction in Washington State

Abstract: This paper summarize the development of new Washington State Department of Transportation (WSDOT) wide flange deck girder system for long span bridges and accelerated bridge construction. The new deck girders could be fabricated using either normal weight or light weight aggregates concretes. Ultra-high performance concrete (UHPC) in lieu of the welded ties and grouted keys is considered for connection between girders to improve the performance of the connection between girders. Precast bridges and culverts consisting of pretensioned deck girders, and precast concrete arches are often used for accelerated construction, and have proven to meet the requirements for durability, longevity, and seismic performance. The recent WSDOT projects utilizing the accelerated bridge construction techniques such as lateral sliding of bridge superstructure are presented, and the use of geosynthetic reinforced soil with integrated bridge system (GRS-IBS) has been discussed.
Session 2 Presentations

2-1  John Stanton, Marc Eberhard, David Sanders, Travis Thonstad and Islam Mantawy. University of Washington, stanton@u.washington.edu

Title: A Bridge Bent System Designed for Rapid Construction and Superior Seismic Performance

ABSTRACT: A new bridge bent system has been developed to provide 1) reduced on-site construction time, 2) minimal residual displacements after even a large earthquake and 3) reduced seismic damage. The rapid construction is achieved by precasting the substructure and by using new connections that can be completed quickly and easily. Residual displacements are minimized by pre-tensioning the columns with strands that are bonded only at the ends, so the strands remain elastic during seismic displacements. The damage in the hinge region is reduced by special confinement details.

An early, non-prestressed, version of the system has been implemented in the field in a freeway overpass over I-5 in Washington State. Construction was straightforward and the connections were completed quickly and easily, thereby demonstrating the system’s rapid construction characteristics. The more recent, pre-tensioned version has almost identical construction features. Its structural response has been tested at the University of Washington at 42% scale, using individual column-to-footing and column-to-cap beam connections and cyclic lateral loading. A two-span, three-bent complete bridge at 25% scale has also been tested under dynamic loading on the shaking tables at the University of Nevada, Reno. In both cases, the residual displacements were extremely small, even after excursions to peak drifts of more than 10% (cyclic loading) and 13% (dynamic loading) and the damage to the concrete was only cosmetic. In the shaking table tests, the capacity of the tables was reached but, after all testing was complete, the bridge was still deemed safe for immediate operation.

The paper reports on the principles underlying the new system, the connection details, and the shaking table tests.

2-2  Atorod Azizinamini, Ph.D, P.E., FL International University – aazizina@fiu.edu

Title: ABC-UTC Research Activities for development of steel bridge systems and details using UHPC applicable to Seismic areas

Description: This presentation will provide brief summary of some of the ongoing research projects at ABC-UTC with emphasis on earthquake engineering. In particular presentation will focus on two projects that are related to earthquake engineering. The first project attempts to develop an economical steel bridge system applicable to high seismic areas. The second project will provide latest ABC-UTC research activities for development of series of innovative seismic details that utilizes UHPC. The use of UHPC in seismic areas has a great potential to provide an economical alternative details that could be used in seismic applications. An example includes column to pier cap connection detail utilizing UHPC. The use of UHPC can completely eliminate the need for having pocket in the pier cap that is very complex in field application.
2-3  M. Saiid Saiidi, PhD, PE, Professor, University of Nevada, Reno, saiidi@unr.edu

Title: Novel materials and concepts for ABC in moderate and high seismic zones

Abstract: Highlights of several investigations on seismic performance of a new generation of bridges are presented. The novelty is in design and detailing in addition to construction. In addition, a completely novel concept of deconstructible of bridge columns and plastic hinges is introduced. Smart materials are utilized in design and detailing of critical column zones for earthquake loading resistance. Specifically, superelastic Nickel-Titanium and Copper based shape memory alloy (SMA) bars are used. The novelty in detailing is in connections between SMA and steel bars outside the plastic hinges. Furthermore, novel detachable connections between plastic hinges and adjoining members are developed and investigated in “design for deconstruction” (DfD). With respect to construction innovation prefabricated members and connections are used. These elements consist of conventional materials or a variety of advanced materials including ultra-high performance concrete, fiber-reinforced polymer laminates and tubes made with carbon or glass fibers, engineered cementitious composites, and SMA bars.

Large-scale column and bridge models have been designed and tested under quasi static or shake table loading and different limit states have been investigated. In DfD studies columns and a two-span bridge model were tested, disassembled, reassembled, and retested under earthquake motions that were simulated on shake tables. Prior and subsequent to the tests extensive analytical studies using different analytical models with a range of sophistication have been used. The presentation will discuss the philosophies, research approach, test models, shake table test videos, analytical studies, and practical implication of research.

2-4 George Ghusn, Jr. SE, LEED AP, SECB, President/Principal, BJG ARCHITECTURE & ENGINEERING, gghusn@biginc.com

Title: Rapid Column System Overview and Design Guide

Abstract: A Seismic Ductility Device (SDD) is a novel structural component providing ductility at the plastic hinge regions of columns using Shape Memory Alloy (SMA) rods and a core consisting of Engineered Cementitious Composite (ECC) and a steel shear pin.

The SDD is designed and prefabricated as a modular element to be placed with the column and pier cap to speed bridge construction and lower costs by enabling pre-cast—instead of cast-in-place—columns. Employing an integrated set of tested technologies, the SCS Rapid Column System SDD provides an efficient and cost effective solution to achieve seismic performance with easy inspection, maintenance and repair.
L-1 Patrick Gallagher, PE, WSDOT – gallagp@wsdot.wa.gov

Title: Update on WSDOT ABC Chapter for the BDM

Abstract: Change often comes with resounding cheers or a deep, low groan. Changing a 6000 year old industry, comfortable with doing things “the usual ways,” is no easy task. This is the story of how the Washington State Department of Transportation (WSDOT) added to its Bridge Design Manual to include policy for Accelerated and Innovative Bridge Construction. It’s a description of how WSDOT is writing policy that encourages change amidst a culture of critics.

WSDOT has a way of doing business that has been established for decades and a way of putting together projects that has served the citizens of Washington well for a long time. Our Bridge Design Manual is intended to educate, explain, direct, and provide standard details. However, our position on policy writing has been to give consultants and contractors a very active role in the design and construction processes. We often write our BDM to give designers and contractors maximum flexibility. In order for ABC to be taken seriously, we had to consider the context in which we were giving direction.

At WSDOT, we often boast about our interests in prefabricated substructures in high seismic regions. We often describe ABC methods as commonplace and without acknowledging that they are already a part of the message that’s being communicated with ABC. But in order for ABC to be fully embraced, we have to get beyond one system, associate familiar methods with ABC, actively promote a host of other systems, tie road and bridge construction together, and encourage other contracting methods to make it successful.

Washington State has successfully built many bridges with ABC methods and contractors are eager to try them when there’s money to be made for them. But in order for the benefits of ABC to be fully capitalized on, our policy has to draw attention to it early in the project development. Our policy has to speak to the audiences that determine the contracting methods, the contractors that will have to install these often large objects, the project managers that will have to get familiar with a new way of building, and the engineers who will have to design and manage the bridges being constructed with ABC. The value of this presentation comes from understanding the unique issues facing WSDOT. It describes the arena of battle where bridge engineers try to educate other engineers who may not be familiar with or interested in ABC. And it describes how a few engineers are trying to reshape the bridge construction industry from the bottom up.
ABSTRACTS

Session 3 Presentations

3-1 Bala Sivakumar, P.E. Vice President, Director-Special Bridge Projects, HNTB Corporation – bsivakumar@hntb.com

Title: Using the SHRP2 ABC Toolkit

Abstract: The ABC Tool Kit developed under SHRP2 R04 and published in 2013 for prefabricated bridge elements and systems (PBES) and extended to cover lateral slide concepts is comprised of the following:

1. ABC standard design concepts for PBES
2. ABC erection concepts for PBES
3. ABC sample design calculations for PBES
4. Recommended ABC design and construction specifications (LRFD)
5. Lateral slide design and construction concepts

This Toolkit is focused on the design and assembly of routine bridges using ABC techniques that would be of value to engineers, owners and contractors new to ABC. The standard concepts, used in conjunction with the ABC sample design calculations and design specifications, will provide the “training wheels” that designers are looking for until they get comfortable with ABC. They include complete prefabricated modular systems for abutments, piers, superstructures; guideline drawings for ABC construction technologies, and lateral slide systems. The presentation will introduce attendees to the contents of the Toolkit and their application to the rapid replacement of workhorse bridges. The ABC Toolkit is available for download on the TRB website. HNTB was the prime consultant for SHRP Project R04 that developed the ABC Toolkit. Bala Sivakumar, Vice President with HNTB served as the Co-Principal Investigator on this project.
3-2 Dusan Radojevic, Ph.D., P.Eng., P.E. Chief Specialist, Buckland & Taylor| COWI, durc@b-t.com

Title: Accelerated Deck Replacement for the Macdonald Bridge

Abstract: The Angus L Macdonald Bridge joins the suburb of Dartmouth with the central business district in Halifax, Nova Scotia, Canada. It is a 1,400 ft mainspan three-lane suspension bridge, the deck of which is nearing the end of its functional life. The bridge is critical to efficient functioning of the city's transportation system and, as such, closing it for rehabilitation would cause significant negative ramifications to the transportation network.

Construction has started on replacing the deck in a manner similar to the way the deck of the Lions' Gate Bridge (LGB) in Vancouver was replaced in 1999-2000, but with important differences. Complete deck segments 65' long (20 m) will be replaced during night-time closures (with some weekend closures) while traffic is maintained during most days (lane closures will be allowed during non-peak hours). Existing deck segments will be cut from the bridge, lowered to water level for disposal and new segments will be lifted into position and secured. This process will be repeated for 46 segments over approximately 24 months of construction.

B&T designed the final bridge. In a significant departure from typical project delivery methods, the Owner of the Bridge – Halifax Harbour Bridges – had B&T also design three major pieces of erection equipment and determine all erection procedures for the contractor (normally the contractor would hire an engineer to carry out this work). Having B&T perform the sophisticated analytical erection analysis work lengthened the design phase but has shortened the overall project schedule as it removed this work from the contractor's critical path.

Winds in Halifax are significantly higher than in Vancouver, adding a layer of complexity that was not present on the LGB redecking project. A "hurricane study" was first carried out to determine possible wind loads in the Halifax area. Results of this study were used in wind tunnel testing of aeroelastic full-bridge models. Wind tunnel results were calibrated to analytical results. Special wind tunnel testing was also carried out for "in-construction" stages (when deck segments are being replaced.)

Other interesting engineering work carried out involved studying movements of suspension bridges under actual traffic loading in order to size the expansions joints at the main towers (bridge codes are not, typically, set up for long span suspension bridge movements). Also, the main cables of the bridge were inspected and found to be in good condition, but wet on the inside. To address this, B&T/COWI designed a cable dehumidification system to dry out the insides of the cables.

B&T is very excited about the opportunity to present all engineering aspects of this project to WashDOT.
3-3  Kevin T. Dusenberry, SE, Jacobs – Kevin.Dusenberry@jacobs.com

Title:  Lateral Slide of Historic Bridge In Washington State

Abstract: To shorten construction time and minimize construction costs, an existing truss was moved to become a detour bridge. Moving of the bridge allowed for use of the existing roadway alignment and infrastructure for the permanent construction. Preserving the existing alignment eliminated the need for retaining walls, barrier and sidewalk modifications to the existing SB bridge, new signals and major utility relocation. The presentation will demonstrate how the 371’ long, 1.5M pound truss was moved and lessons learned along the way.

3-4  Gregory A. Banks, PE, ABAM – Greg.Banks@abam.com

Title:  Boeing North Bridge: Lessons Learned in Accelerated Bridge Construction

Abstract: The Boeing North Bridge is a multi-span girder bridge spanning the Cedar River in Renton, Washington. All aircraft assembled in the Boeing Company factory get towed over the bridge in order to access Renton Municipal Airport where the aircraft undergo final inspections before taking-off from the airport. The design and construction schedule for the bridge was accelerated in order to meet Boeing’s increased production rate and plans for production of a new line of aircrafts. In response to the accelerated schedule and its impacts on construction activities around environmental work windows, the winter construction season, the airport, and surrounding residents, the new bridge was designed utilizing precast columns, precast crossbeams, and full-depth precast deck panels. Due to the high seismicity of the bridge site, the connections between precast substructure components had to be seismic resisting. This paper summarizes the details of the pre-fabricated bridge elements and documents decisions made by the design team to use prefabricated bridge elements. These decisions are then contrasted with the construction methods the Contractor requested to follow.
Resources Available through the ABC University Transportation Center (ABC-UTC)
by
Mary Lou Ralls, P.E., Ralls Newman, LLC

WSDOT 2015 ABC Workshop
Tumwater, WS
April 1, 2015

Presentation Outline
• Introduction to ABC-UTC
• ABC-UTC website
  – Home
  – Research Projects
  – Education
  – Technology Transfer
  – Resources
  – Events
  – News

ABC-UTC
Award Announcement: September 2013
Consortium of Universities:
• Florida International University (FIU)
  • Atorod Azizinamini (lead)
• Iowa State University (ISU)
• Brent Phares & Terry Wipf
• University of Nevada, Reno (UNR)
• Saiid Saiidi
ABC-UTC Collaboration

- American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures (SCOBS)
  - Technical Committee for Construction (T-4)
  - Technical Committee for Seismic Design (T-3)
- Transportation Research Board (TRB) ABC Subcommittee
- ABC-UTC Steering Committee

ABC-UTC Focus Areas

- Research
  - 11 ongoing projects, initiated in 2014
  - Will be considering additional projects for 2nd round funding in near future

Note: An advisory committee has been formed for each ongoing research project to monitor progress

ABC-UTC Focus Areas

- Education and Workforce Development
  - Increase ABC research assistantships for graduate students
  - Mentor undergraduate & graduate students in ABC
  - Develop undergrad ABC research intern program
  - Add ABC course content at university level
  - Develop online ABC courses
  - Develop K-12 educational modules
ABC-UTC Focus Areas

• Technology Transfer
  • Created dedicated website (www.abc-utc.fiu.edu)
  • Continuing to post various content
  • Soon to post the FHWA projects database
  • Producing monthly 1-hour webinars

ABC-UTC Focus Areas

• Technology Transfer, cont’d.
  • Hosting 4-hour in-depth web trainings
    • 2014 & planning 2015
  • Hosting National ABC Conferences
    • 2014 & planning 2015
  • Presentations at national bridge meetings
  • “Highlights” report in 2015
2015 National Accelerated Bridge Construction Conference
December 7 and 8, 2015
Workshops December 6, 2015
Hyatt Regency, Miami, Florida

The 2015 National Accelerated Bridge Construction Conference will be held on December 7 and 8, 2015, at the Hyatt Regency hotel, in downtown Miami, Florida. The 2014 National Accelerated Bridge Construction Conference that was held in the same hotel, during June 4 and 5, 2014, was a great success. More than 700 attended the conference. Among attendees were more than 100 state bridge engineers, more than 40 FIPMA bridge engineers and many consultants and bridge offices. Acting Administrator of FIPMA, Mr. Gregory Nieszko,

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ABC-UTC Research Projects

- Florida International University (FIU)
  - Compilation of All ABC Research-Ongoing & Completed
  - Compilation of Available Short to Medium Span ABC Systems
  - Extending Application of Simple for Dead & Continuous for Live Load Steel Bridge System to ABC Applications in Seismic Regions - Phase I, Numerical Study
  - Estimating Total Cost of Bridge Construction using ABC and Conventional Methods of Construction
  - Development of Manual for Enhanced Service Life of ABC Projects
ABC-UTC Research Projects

- Iowa State University (ISU)
  - Development of Prefabricated Bridge Railings
  - Strength, Durability, and Application of Grouted Couplers for Integral Abutments in ABC Projects
  - Synthesis: Rapid Bridge Rehabilitation

ABC-UTC Research Projects

- University of Nevada at Reno (UNR)
  - Behavior and Design of Precast Bridge Cap Beams with Pocket Connections
  - Evaluation of Seismic Performance of Bridge Columns with Couplers and Development of Design Guidelines
  - Development and Seismic Evaluation of Pier Systems with Pocket Connections and Hollow PT/UHPC Columns
State DOT Websites with ABC Content – currently listed on ABC-UTC Website (Resources)

- Iowa
- Massachusetts
- Oregon
- Texas
- Utah
- Washington State
Overview of Precast ABC Projects in the Pacific Northwest
Chuck Prussack, P.E., Oldcastle Precast, Inc - Spokane

Techniques

- Additional prefabrication of units to reduce field timeline
- Simplify deck installation to reduce field forming
- Precast substructure elements
- Match elements to site constraints – spans, traffic needs, soil parameters
- Use proven details

Goal of all techniques is Accelerated Bridge Construction

Dayton Street Bridge Replacement, Kennewick, WA

- 12" Soliddeck, 46′ x 4′ (16 pieces); abutments with footings (6 pieces), 36° skew
- Contractor: Accelerated Construction and Excavating, Plummer, ID
- Owner: City of Kennewick, WA

Longitudinal elevation of abutment 2

Abutment cross-section
Dayton Street Bridge Replacement, Kennewick, WA

- Three-piece sloped abutments
- Edge to edge deck simplified deck pour
- Tight timeline due to school session

Dayton Street in process

Dayton Street Bridge Replacement, Kennewick, WA

Finished job – just in time to re-open for school

Kittitas Highway, WA

- 18" Soliddeck, 36'-6" x 4' (8 pieces); abutments with footings (7 pieces), 62° skew
- Contractor: Belsaas & Smith Construction, Ellensburg, WA
- Owner: Kittitas County Department of Public Works, WA
Kittitas Highway, WA

Abutment walls with footing being set

Kittitas Highway, WA

Deck being set

Swan & Willow Creek Bridges, Kootenai County, ID

- Contractor: Apollo, Inc, Kennewick, WA
- Owner: Idaho DOT
- Swan Creek –
  - Three-sided Box Culvert (9 pieces)
  - Precast headwalls (2 pieces)

Swan in process

Swan complete
Swan & Willow Creek Bridges, Kootenai County, ID

- Willow Creek –
  - Tri-deck (8 pieces)
  - Precast pile caps (4 pieces)
  - Plant precast parapet barriers (2 pieces)
  - Edge-to-edge deck elements

Deep Creek Structures, Broadwater County, MT

- Three tri-deck bridges (15 pieces), pile caps (6 pieces)
- Curbs cast on at plant
- Different slopes and elevations
- Weekend highway closures for each bridge replacement; 24-hour work schedule
- 100 mile detour; some trucks on far side for delivery
- Trial fit in precast yard
- Contractor: Dick Anderson Construction, Great Falls, MT
- Owner: Montana DOT
- Consultant: Morrison – Maierle Engineers
Deep Creek Structures, Broadwater County, MT

Trial fits in precast yard

Deep Creek Structures, Broadwater County, MT

Pile cap being placed

Deck being placed

Deep Creek Structures, Broadwater County, MT

One bridge complete, keyways grouted
Swiftcurrent Bridge, Glacier National Park, MT

- 30" Voided slabs, 85' x 4'5" (6 pieces), abutments (2 pieces), wing walls (4 pieces), deck overhang
- Post-season, pre-winter install; crane on far side of creek
- Trial fit in precast yard
- Contractor: Northbank Civil & Marine, Vancouver, WA
- Owner: USDOT, Federal Highway Administration

Swiftcurrent Bridge, Glacier National Park, MT

- Note color of exterior girders to diminish visibility of depth
- Secondary pour of overhang to reduce field time
- Utility pipe cast in to voids at plant (5 places)

Swiftcurrent Bridge, Glacier National Park, MT

- Set in progress
Swiftcurrent Bridge, Glacier National Park, MT

- Finished bridge

French Creek Bridge, Gallatin National Forest, MT

- 15” Solid slab 37’ x 4’ (4 pieces), grade beams (2 pieces), wing walls (4 pieces)
- Contractor: Battle Ridge Builders, Belgrade, MT
- Owner: U.S.D.A. Forest Service Region 1

Glover Creek Bridge, Clearwater National Forest, ID

- Trideck 37’ x 4’ (4 pieces), grade beams (2 pieces), abutments w/footings (3 pieces), wing walls (2 pieces)
- Colored concrete with stone pattern on abutment walls and wing walls
- Contractor: Cook & Sons, Whitebird, ID
- Owner: U.S.D.A. Forest Service Region 1
Glover Creek Bridge, Clearwater National Forest, ID

- Typical large plant-cast USFS curbs

Finished bridge in place  Stone pattern repair

Summary

- Use of full deck horizontal elements
  - To minimize field forming
  - To expedite deck timeline
- Precast substructures with just in time delivery
  - To avoid jobsite congestion
  - To expedite substructure timeline
- Wide array of precast elements are available depending on the type of abutment
  - Spread footing or pile cap
  - Deck type differs depending on span
  - Appurtenances such as curbs, parapet, or railing
  - Aesthetics can be addressed with all of the available precast expertise
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
  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 12-105: 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

PBES – Implementation

From: Summit -1: P2P Exchange - PBES

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)

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<th>Girder Depth (in.)</th>
<th>Guyon Efficiency Factor</th>
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<td>0.56</td>
</tr>
</tbody>
</table>

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)

Efficiency Of Prestressed Girders

<table>
<thead>
<tr>
<th>Girder Depth (in.)</th>
<th>Guyon Efficiency Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.40</td>
</tr>
<tr>
<td>30</td>
<td>0.42</td>
</tr>
<tr>
<td>40</td>
<td>0.44</td>
</tr>
<tr>
<td>50</td>
<td>0.46</td>
</tr>
<tr>
<td>60</td>
<td>0.48</td>
</tr>
<tr>
<td>70</td>
<td>0.50</td>
</tr>
<tr>
<td>80</td>
<td>0.52</td>
</tr>
<tr>
<td>90</td>
<td>0.54</td>
</tr>
<tr>
<td>100</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Span = 8 – 10 feet above tracks

December 2011 Concrete Products Article by Don Marsh
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

---

**Geosynthetic Integrated Bridge System**

---
MSE wall supported abutments
GRS supported abutment – flat slab superstructure with no footing and dry-cast modular block wall facing

- 8 in. high by 12 in. wide precast concrete beam full width of slab
- #4 rebar, grouted in place
- Min. vertical clearance of 4 in.
- Compressible material (provide min. 4 in. thickness)
- Primary reinforcement
- Secondary reinforcement (max. vertical spacing of 8 in., min. length of 4 ft behind facing), if primary reinforcement spacing is greater than 12 in.
- Precast voided or slab superstructure (void is min. 1 ft from facing)
- Surfacing

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

<table>
<thead>
<tr>
<th>Bridges and Culverts</th>
<th></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>
Preliminary Design Aid: Span, Rise, Fill, Precast Arch Dimensions, etc.

Precast Concrete Culvert Standardization

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

WSDOT ABC Website

Thank You!
ACCELERATED BRIDGE CONSTRUCTION
IN SEISMIC REGIONS:
RESEARCH AT THE UW

John Stanton
Travis Thorstad
WSDOT ABC Workshop
1 April 2015

Acknowledgments

Funding:
NEES
PEER Center
FHWA Highways for Life
WSDOT
TransNow Center
PacTrans Center
Valle Foundation

Accelerated Bridge Construction
Use:
• Incentives in contracting
  - Place value on time.
• Big toys
  - Slide-in, SPMTs, etc.
• Precast Elements and systems
  - Prefabricate off-site, assemble on-site

Accelerated Bridge Construction

• Prestressed girders are already pre-fabricated.
• Concentrate on substructure (bridge bents)
• Connections are the key
  - Ease of assembly (simplicity, speed, tolerances)
  - Seismic resistance

Systems Developed
Spread Footing Connection

- "Wet Socket" connection
- Precast column
  - Can be built in a plant.
  - No projecting bottom bars.
  - Easy transportation.
- Cast in place footing
Wet Socket – Lab Specimen

Shear friction steel (placed diagonally)

Footing ties

Footing Connection - Forces

Strut and Tie Model.

Headed bars provide excellent anchorage. Footing ties not needed.

Test Results

- **Lateral load:**
  - Behaved exactly as conventional cast-in-place, but
  - footing ties experienced very low stress
- **Vertical load**
  - Loaded to 3.5 times factored load: footing not even cracked
Spread Footing Connection

After lateral load testing. Foundation undamaged.

Field Implementation

Tri-State Construction. SR520, Redmond

Re-centering Low Damage System
Re-Centering Low Damage System

- Precast column for fast on-site construction.
- Use unbonded prestressing to re-center the column. Rocking minimizes column damage.
- Pre- (not post-) tension the column.
- Connections:
  - Bottom: Wet socket
  - Top: New ("Dry Socket")

Partially Unbonded Pre-tensioning

Strand: Stays elastic, provides re-centering force
Rebar: Yields and dissipates energy
Low-Damage, Rocking Behavior

Bending: Tension cracks and compression crushing inevitable

Rocking: High contact stresses

Detailing Strategies

Conventional concrete only

HyFRC in plastic hinge region

Steel tube confinement

“Wet Socket” Spread Footing Connection
"Grouted-Bar-Socket" Cap Beam Connection

Connections are critical!

Subassembly Tests
Test Configuration

Axial Load = 159 kips

Observations

After 10% drift:
- No concrete damage,
- No footing damage,
- No cap beam damage.
- Rebars broken (6%)
- Strand yielded (3%)

Column Performance

After 10% drift:
- Limited strength degradation (over 80% peak strength)
- Returns to within 0.1 of residual displacement
Shake Table Test

Specimen Dimensions

- Two-span portion of a typical bridge in the western United States supported by two column bents on drilled shafts.

2005 RC Bridge Motion 19 (220% Design Level)
1994 Northridge - Century City CC North (PGA=1.66g)
2005 RC Bridge Motion 19 (220% Design Level)
1994 Northridge - Century City CC North (PGA=1.66g)

- Bent 3 columns fully spalled, spiral fracture, bar buckling.
- Load over bent 3 was removed due to safety concerns.

Shake Table Test → 2005 RC Bridge Motion 19 (220% Design Level)

---

2014 PreT Bridge Motion 19 (220% Design Level)
1994 Northridge - Century City CC North (PGA=1.66g)

- Hairline horizontal cracks (3 in total) minor flaking at steel tube,
- rebar fracture, bulging of steel confining jackets.

Shake Table Test → 2014 PreT Bridge Motion 19 (220% Design Level)
2014 PreT Bridge Motion 21C
1995 Kobe – Takatori Station (PGA=0.8g)

- Columns were vertical
  - Residual Drift < 0.2%
  - Essentially no damage to concrete

Column Performance

Shake Table Test → Specimen Comparison
Conclusions

Performance Goals: Accelerated Construction

- Easy, rapid assembly on site.
- Precast cap beam saves a lot of time.
- Critical components (e.g. prestressing) done in plant under good QC.
- No Post-Tensioning needed on site.
- No anchorages susceptible to corrosion.
- Uses only common construction materials.

Performance Goals: Improved Seismic Performance

- Zero residual drift even after 13% peak drift.
- Concrete damage only cosmetic even after 13% drift.
- Bridge safe for emergency vehicles after motion with pga = 1.66 g (Motion 19).
- Strand remained elastic to 3% drift, as designed. (Could go higher if desired.)
- First rebar fracture at 6 – 7% % drift, as designed. (Could go higher if desired.)
Thank You
Development of SDCL Bridge System for High Seismic Application

By
Atorod Azizinamini, Ph.D., P.E.
Professor and Chair
Director, ABC-UTC
CEE Department
Florida International University

April 1, 2015
WSDOT, 2015 ABC Workshop

Moment Diagram

Dead Loads

Live Loads

Conventional System  SDCL System

Construction Sequence

Conventional construction

Place steel girders over support

Connect the steel beams over the pier by filling ½ to 2/3 of the concrete diaphragm

This eliminates line of cross frames over the support
And enhances the durability of connection
Construction Sequence
Conventional construction

Final step - Place the deck

Under negative moment, tension over the support is resisted by steel reinforcement

Tensile forces are resisted by steel reinforcement

Need for mechanism that could resist the compression
Non-Seismic detail was developed through selecting potential solutions and developing design provisions through combination of Experimental, numerical and analytical work.

**SPECIMEN No.1**
Direct Transfer of Compression Force

**SPECIMEN No.2**
No End Detail
ULTIMATE LOAD TEST – Simulating Negative moment over middle support

- Test 1, 0 Cycle
- Test 1, 2M Cycles
- Test 3, 30000 Cycles
- Test 3, 2M Cycles

Micro Strain at Section A-A

Depth of Girder (in)
SDCL
Conventional Application
I girder
SDCL
Conventional Construction
Box Girder
<table>
<thead>
<tr>
<th></th>
<th>Normal Light (120)</th>
<th>Normal Light (120)</th>
<th>Normal Light (120)</th>
<th>Normal Light (120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>25.6</td>
<td>25.6</td>
<td>25.6</td>
<td>25.6</td>
</tr>
<tr>
<td>Deck</td>
<td>58.1</td>
<td>46.5</td>
<td>71.5</td>
<td>57.2</td>
</tr>
<tr>
<td>Total</td>
<td>83.7</td>
<td>72.0</td>
<td>97.1</td>
<td>82.8</td>
</tr>
<tr>
<td>Rail</td>
<td>18.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.5" SubDeck  
8" Full Depth
Examined the suitability of the same connection used for non-seismic area for application in high seismic areas by subjecting a two span steel bridge to number of Ground motions.

**Time History Analysis**

- Eight earthquake records were selected, scaled to AASHTO’s response spectrum and applied in the model.

<table>
<thead>
<tr>
<th>Earthquake Name</th>
<th>Scale Factor</th>
<th>Year</th>
<th>Station Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Fernando</td>
<td>3.3358</td>
<td>1971</td>
<td>Palmdale Fire Station</td>
</tr>
<tr>
<td>Imperial Valley-06</td>
<td>1.9876</td>
<td>1979</td>
<td>Cerro Prieto</td>
</tr>
<tr>
<td>Izmit</td>
<td>2.1188</td>
<td>1980</td>
<td>Italy</td>
</tr>
<tr>
<td>Loma Prieta</td>
<td>3.6419</td>
<td>1989</td>
<td>Anderson Dam (L. Abut)</td>
</tr>
<tr>
<td>Northridge-01</td>
<td>2.4706</td>
<td>1994</td>
<td>Sunland - Mt Gleason Ave</td>
</tr>
<tr>
<td>Duque</td>
<td>3.407</td>
<td>1999</td>
<td>Turkey</td>
</tr>
<tr>
<td>Manjil</td>
<td>0.7572</td>
<td>1990</td>
<td>Iran</td>
</tr>
<tr>
<td>Darfield</td>
<td>1.2595</td>
<td>2010</td>
<td>New Zealand</td>
</tr>
</tbody>
</table>
Results indicated that there is possibility of Bottom flanges being subjected to tensile, Forces, which demands bottom flanges To be connected.

To develop a better idea on demand side with Respect to internal forces in the concrete Diaphragm, detail FE analysis are carried out

It is also recognized that the type of forces that Connection over the pier will be subjected During major earthquake will be complex and That may not be well enveloped by merely Subjecting number of prototype bridges to Non-linear time history dynamic analysis.
Very detailed FE model was developed to gain a better understanding of:

a) Suitability of non-seismic detail for seismic application

b) Modes of failure

c) Modifications to detail that are needed for application to high seismic areas

Integral Connection - Bottom flange not connected
Results clearly shows that non-seismic Detail needs modifications.
For sake of clarity the concrete diaphragm is not shown

Connection detail for Pier Cap Beam to Column Using UHPC for ABC Application in High Seismic Areas
Cap Beam to Column Connection
Detail to be tested

Some of the Reinforcements are Eliminated to force Plastic Hinge Formation

Connection Detail

Advantages

- Eliminates modifications needed for cap beam reinforcement
- Large tolerances
- Plastic hinge forms at a distance away from cap beam
- Use of UHPC allows development of reinforcement using smaller length

Test Setup (Loading Detail)
Thank You

Atorod Azizinamini
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402-770-6210
Novel Materials and Concepts for ABC in Moderate and High Seismic Zones

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Professor, Department of Civil and Environmental Engineering

Research Assistants
Mostafa Tazarv, PhD, Post-doc
Sebastian Varela, PhD
Fatemeh Kavianipour, PhD
Brian Nakashoji, MSCE

Question: Why novel materials?

• ABC already presents challenges even with conventional concrete and steel

• Answer:
  Challenges = Opportunities
  …opportunities to raise the bar.
  >>>>Improve seismic performance
Novel Materials in Earthquake Design

- Performance during earthquake
- Serviceability after earthquake

Novel Concept in Earthquake Design
- Design for deconstruction (DfD)

Target performance for standard bridges during earthquake: No Collapse

Not Good! OK!

- Serviceability after earthquake:
  - Minimize permanent drift and damage
- Performance-based design
- Isolated systems
- Advanced materials/details
  - Shape memory alloys
  - Ductile concrete/UHPC
  - Columns w/ built-in elastomeric pads
  - Fiber-reinforced polymers
  - Post-tensioning
Concrete + Steel >> One Combination

Advanced Materials/Details >> Over 40 Combinations

Only 8 have been proof tested (mostly for CIP construction)!

Novel Materials (Research on ABC in high seismic zones)

• Shape memory alloys (SMA)- Nickel Titanium, Cu-based, etc.
• Engineering cementitious composites (ECC)
• Ultra-high performance concrete (UHPC)
• Rubber
• Fiber reinforced polymers (FRP)- glass, carbon, etc.; fabrics, hard shell, etc.
SMA (Nickel Titanium)

Also military applications

Shape Memory Alloy

- Superelastic response
- Shape memory effects
- NiTi SMA developed in 1962
- Cu-Al-Mn SMA being developed

Superelastic SMA bars eliminate permanent drift

Engineered Cementitious Composites (ECC, “Ductile Concrete”)
Ultra-High Performance Concrete (UHPC)

- Significantly higher compressive and tensile ductility
- Five times higher compressive and tensile strength

Compared to Conventional Concrete

UHPC-Filled Duct Column Connections

- Two Prefabricated Column Models
  - Conventional Materials in Plastic Hinge ("PNC")
  - SMA-ECC in Plastic Hinge ("HCS")
- Connection to Footing
  - UHPC-Filled Duct Connections
- Column Geometry
  - Half-Scale: Hollow; Filled w/ SCC after connecting
  - Height: 9.8 ft (2.74 m)
  - Diameter: 24 in. (610 mm)
  - 11-#8 (Ø25 mm) Longitudinal Bars (ϕL=1.92%)
  - Spiral, ϕS=1.03%
  - Axial Load Index: 10% (200-kip axial load on specimens)

Column ABC Connections w/ UHPC Grouted Ducts
Low-Damage Precast Column w/ UHPC Grouted Ducts

- Headed Coupler
- Columns tested by Haber et al. (2014), emulative performance
- SMA-Reinforced ECC section
- UHPC-Filled Duct Connection

UHPC-Filled Duct Columns Connections - Construction

- Cantilever Configuration
- Displacement-Control Loads

Drift = Head Displacement/Height
UHPC-Filled Duct Column Connections - Performance

PNC vs. reference Cast-in-Place Model (CIP)

9% Drift Capacity

Low-Damage Precast Column

Test Results: Force-Drift

UHPC-Filled Duct Column Connections - Test Results

PNC, HCS, and CIP Test Average Envelopes
UHPC-Filled Duct Connections

Columns w/ UHPC-Filled Duct Connections

PNC  HCS  CIP

@ 10% Drift Ratio

UHPC-Filled Duct Connections

After the test to 12% drift

Columns w/ UHPC-Filled Duct Connections

PNC  HCS

No damage of UHPC-filled duct connections even after 12% drift cycles

Innovative Details

Concrete filled tube post-tensioned columns
Concrete filled tube CIP columns
Pipe pin

Concrete filled tube precast columns
Post-tensioned segmental columns wrapped with CFRP
Design for Deconstruction (DfD)

Objectives:

1. Withstand strong earthquakes with no or minor damage so they are usable after earthquakes.
2. Can be disassembled and reused.

Note: 5% of CO₂ emission in the world is from cement factories.
ECC; NiTi; Copper Based SMA; Rubber; CFRP Shell

(Remark Filed)

Column Test Models

Two-Span DFD Bridge
Summary

• ABC provides opportunity to embrace innovation.
• With novel materials and details ABC can go beyond emulative seismic connections.
• Permanent drift and plastic hinge damage can be reduced substantially with innovative materials and details.
• The DfD bridge takes ABC yet another step further. With sufficient research and deployment we may recycle obsolete bridges in the future.
WHAT IS A SEISMIC DUCTILITY DEVICE?

- A SDD is a structural element designed to:
  - Provide the ductility necessary to prevent collapse through:
    - Release of elastic energy through hysteresis
    - Self centering due to super-elastic material
  - Protect other elements of the structure from overload
    - Lower stiffness - moves bridge fundamental period
  - Provide for modular repair of the device or portions of the device designed to accept damage.
  - Integrate with Accelerated Bridge Construction (ABC) methodologies techniques to allow modular construction of ductile precast concrete columns.

PRINCIPLES OF THE SCS SDD

- Take the forces developed by earthquake loads and use specific materials/techniques to transmit them.
- Each force path has specific characteristics to either carry the force or modify it by deforming as needed:
  - Compression: force can be directly transmitted by concrete.
    - The goal is to minimize crushing and insure that any crushing is very limited to minimize possible catastrophic failure.
  - Shear: Transmit the shear without interaction in tension or compression that may combine to increase damage.
  - Tension: use tension connections that can absorb energy by stretching without permanent damage.
THE UNIVERSITY OF NEVADA RENO
COLUMN BASE UNIT

- This test unit was built by SCS's parent company, Fibermatrix.
- The unit was placed at the bottom of a single column representative of a bridge column.
- Results and specifics are summarized in Dr. Saiidi's presentation.
- Testing produced outstanding results for performance and reparable.
- Column has to be disassembled to access SMA rods.

THE SDD: UNR AND SCS VERSIONS

- ECC carries compression
- SMA carries tension
- Shear pin transfers shear

The SCS SDD moves the rods outside the column.
The rods are protected by a non-structural fairing.

THE STRUCTURAL COMPONENT SYSTEMS SDD

- Practical considerations place SDD between column and beam or column and foundation or both.
- The SDD uses the same concepts and materials as the UNR CBU.
- The SDD has a beam connection plate that has embedded rods into the beam. These rods are stronger than the SMA rods (in red) - thus the SMA rods will stretch before the embedded rods.
- The column rebars extend through the core and anchor in the top of the ECC core.

The SMA rods are outside the core and can be inspected and replaced from the bottom without taking the bridge out of service.
The interaction diagram shows that the SDD has characteristics nearly identical to the ordinary column until substantial moment is introduced. The SDD is then weaker than the ordinary column.
The SDD has structural properties identical to those of the column under normal conditions - no additional vertical deflections.

The SDD is softer than the column, lengthening the period of the structure.

The SDD's ECC and SMA components do not degrade.

The SMA rods, which are the most likely portion of the SDD to be damaged, are easy to inspect and repair. As the SMA rods will not be active for ordinary gravity loads for most designs, replacement of the rods can be accomplished without taking the bridge out of service.

The non-structural fairing allows architectural styling to be separate from structural concerns and provides an enclosed space for instrumentation or signage.

Status:
- Patent application has been submitted to USPTO.
- SCS is currently working with Granite Construction on SDD column assemblies as an alternative for bridges on a new highway - the Southeast Connector project in Reno Sparks.
What is ABC?

- It's an idea:
  - Speed up bridge construction.
  - Creativity Through:
    - Contracting Methods
    - Prefabricated Bridge Elements and Systems
- Shows Itself Locally as:
  - Precast Bridge Piers
  - Geosynthetic Abutments
  - Precast Deck Panels
  - Deck Bulb Tee Girders
  - Lateral Sliding of Superstructures

What is Innovation?

- Anything different with the intent of improving a bridge or it’s construction.
- Normal Bridge Construction:
  - Mostly Cast in Place
  - Prefabricated Girders
  - Concrete or Steel Girders
- Innovative Bridge Construction:
  - Slide Bridges
  - Precast Substructures
  - Build Much of the Bridge Off Site
Innovation versus ABC

**Innovation**
- Generator of new ideas.
- Encourages new ideas at any stage and any level of the project.
- Creates new technologies.
- Focuses on any aspect of bridge creation. It may include:
  - Seismic Performance
  - Durability
  - Service Life
  - Other Desired Results

**ABC**
- Application of innovation.
- Aimed at rapid bridge construction.
- Focuses on:
  - Construction Time
  - Work Off Site
  - Contracting Methods
  - Incentivizing Contracts
  - Combining PBES
  - Safety
  - Protecting Environment

Why Push ABC?
- We’re already doing it!
- Population increase outpaces road construction.
- Population increase outpaces industry changes.
- Public expectations change.
- Underutilized technology is available.
- FHWA incentivizes it.
- Funding is becoming scarce.
- It’s time to move on.

Broader Context
- ABC is a new application of old ideas.
- PBES
  - Stone Arch – Steel Beam
  - Prestressed Girder – Precast Pier
- Contracting Methods
  - Master Builder – Design Build
  - DBB, CMGC, ABCDB
  - Hammurabi’s Law – Incentives
  - Forced Labor – Prevailing Wage
- Innovation
  - “Old-New” Materials
    - Stone, Wood, Steel, Concrete
  - “New-New” Materials
    - HPC, SCC, SMA
  - Paint – Weathering Steel
Purpose of the BDM

- Establishes policy on the things that matter to WSDOT.
- Is one in a series of documents.
  - Linear path of project development: DM, GDM, BDM, CM, Others....
  - A bridge is a small, detailed piece of a larger project to build roads.
- The text generally does these things:
  - Explain
  - Educate
  - Direct
  - Give Design Aids

BDM Philosophy

- The Audience
  - WSDOT Engineers
  - Consultant Engineers
  - Contractors
- Bridge Focused
  - ABC is more than bridges.
- Hands off Approach
  - Make policy flexible to encourage creativity.
  - Give direction only where necessary.

Why Add Chapter 15?

- FHWA said so....
  - One of our responses to the EDC Initiative.
  - Time is valuable.
  - Land is expensive.
  - Wildlife is becoming scarce.
  - Population growth is outpacing capacity to build.
- Good policy is good business.
  - Our position on ABC.
  - Uniformity on a massive system of roads.
  - Explaining our Precast Bent system.
  - Provides some recourse when projects turn sideways.
The Challenge
- The Bridge Design Manual is specific to bridges, ABC is not.
- ABC and Innovation is an abstract concept that transcends many areas of project delivery.
- What defines ABC and Innovation changes.
- The audience of the BDM is Bridge Engineers.
- Bridge engineering details get introduced into project development late.
- The "bridge" component is technical and focused. The ABC "idea" is not.

Moving Target
- How do you codify an idea that changes?
- The lines defining ABC are blurry.
  - Context defines the line defining ABC, Innovation, and "normal."
  - We're already doing many of these things.
- The BDM gets revised regularly.
- Get a little lofty in the language.

Vision Behind Chapter 15
- Provide a broad perspective.
  - ABC and Innovation are more than Precast Bents.
- Provide technical guidance on Precast Bents.
  - DBB and DI
  - The DB BDM is not a guide. It's a required document!
- Be a resource for Regions.
- Be a resource for Bridge Engineers.
- Be a self contained document.
  - Contain bridge items within the same chapter.
  - Contain region items within the same chapter.
- Eventually be incorporated into other design guidelines.
Content

- Four Focus Areas:
  - Items Concerning Regions
  - Items Concerning Bridge Design
    - Articles 15.3 and 15.4
  - Items Concerning Constructability
    - Articles 15.5 and 15.6
  - Inspiring Other Applications
    - Article 15.7
  - Precast Piers
    - Article 15.3.1
      - WSDOT’s Biggest Contribution
      - Specific Direction Given Here
  - Precast Bent System
    - Description of System
    - Design Philosophy
    - Design Provisions
    - Geometry and General Requirements
    - Joint Design for SDC A
    - Joint Design for SDC B
    - Joint Design for SDCs C and D
    - Socket-Type Footing Connections
    - Drilled Shaft
    - Integral Cap Beam

Items Covered Elsewhere

- PBESs in the R&D Phase:
  - Self Centering Columns
  - Shape Memory Alloy and Engineered Cementitious Composite
- Contractor Items:
  - SPMT
  - Lateral Sliding
  - Lifting Weights
  - Member Size
- Other Disciplines:
  - Geosynthetic Retaining Walls
  - Items not Needing Special Policy:
    - Precast Deck Panels.
Content Control

- Three Levels of Detail
  - Vague by Design
    - Items covered elsewhere in WSDOT Policy.
    - Geosynthetic Retaining Walls
    - Precast Deck Panels
    - Contracting Methods
    - Construction Methods
  - Detailed by Design
    - Items not covered elsewhere in WSDOT Policy.
    - Precast Piers
  - Vague for Now
    - Items not code ready, and will not be covered elsewhere in WSDOT Policy.
    - SMA, ECC
    - Self Centering Columns

Explain

- How do you describe abstract ideas to engineers?
- Article 15.7
  - Gives examples and shows pictures
- Article 15.3
  - Gives detail
- Article 15.2
  - Gives applications
- Article 15.1.1
  - Points to other resources:
    - Accelerated Bridge Construction Manual, Publication Number FHWA-HIF-12-013
    - Development of a Precast Bent Cap System for Seismic Regions, NCHRP Report 6th
    - Connection Details for Prefabricated Bridge Elements and Systems, Publication Number FIP6A-IF-09-010, March 2009

Educate

- We control the BDM, we don’t control the DM.
- We must say something, and the BDM is ours.
  - By the time a project develops into needing the BDM, many decisions are made.
  - Say something anyways!
- Target your audience:
  - Articles 15.1 and 15.2 are for the region.
  - Articles 15.3 and 15.4 are for the designer.
  - Articles 15.5 and 15.6 are for the contractor.
  - Article 15.7 is for everyone.
Direct

- WSDOT’s most unique contribution is the precast pier.
  - Article 15.3 gives specific design guidance on precast piers.
  - Article 15.4 will eventually provide guidance on Self Centering Columns and Shape Memory Alloy.
- Acknowledge the contribution of others.
  - Many PBESs are already available at WSDOT.
  - Articles 15.3.2, 15.3.3 and 15.4 refer to other places for design guidelines, or leave out specific policy, putting responsibility on the engineer.
- Articles 15.5 and 15.6 provide direction for the usual design case, ensuring constructability.

Design Aids

### Decision Making Matrix

<table>
<thead>
<tr>
<th>Duct Embedment</th>
<th>Nominal Tube Dia (in.)</th>
<th>Embedment Length / Bar Diameter (in.)</th>
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<tr>
<td>#3</td>
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### Inspire

- ABC is a concept not direct instruction.
- Application of a concept can start off vague.
- Photos in Article 15.7 inspire new applications.
Future Efforts

- Provide Standard Details for Precast Bent Systems.
- Write specific guidelines for Self Centering Columns and Shape Memory Alloy.
- Incorporate design guidelines for other PBES.
- Disseminate the information into the other manuals.
- Disseminate the information into other chapters of the BDM.
- Incorporate new technologies as they develop.

Conclusion

Where we’re going, there might not be roads.....
But there will be bridges.

Questions?

Patrick Gallagher, PE
WSDOT Bridge and Structures
(360) 705-7464
gallagp@wsdot.wa.gov
Delivery of ABC: WSDOT Workshop

Using the SHRP2 ABC Toolkit

Bala Sivakumar
HNTB Corp.

INNOVATIVE BRIDGE DESIGNS FOR RAPID RENEWAL
2007 -- 2013

HNTB (Prime)
Iowa State University
Structural Engineering Assoc.
Genesis Structures, Inc.

SHRP2 Project R04

Goal
To develop standardized approaches to designing and constructing complete bridge systems that address rapid renewal needs

Make Accelerated Bridge Construction Standard Practice
SHRP2 ABC TOOLKIT

- Published by TRB in 2012
  - ABC concepts for PBES
- Addendum in 2014 to cover Slide-In Bridge Construction

SHRP2 R04 Website

SHRP2 R04 ABC Toolkit

1. ABC STANDARD DESIGN CONCEPTS
2. ABC ERECTION CONCEPTS
3. ABC DESIGN EXAMPLES
4. ABC DESIGN SPECIFICATIONS (LRFD)
5. ABC CONSTRUCTION SPECIFICATIONS

Expected Outcome: The designer, guided by the sample drawings, and ABC design examples will be able to easily complete an ABC design.
14 Day Bridge Replacement
PBES Demonstration Project
Keg Creek Bridge, Iowa

Total prefabricated bridge
- 14 day ABC period
- Opened Nov 1, 2011

Standard Design Concepts For PBES
- DECKED STEEL GIRDERS
- DECKED CONCRETE GIRDERS
- PRECAST ABUTMENTS & WINGWALS
- PRECAST PIERS
- PRECAST FOOTINGS
- PRECAST APPROACH SLABS
- ABC CONNECTIONS
Prefabricated Decked Beam Elements

Deck Bulb Tees

Double Tees

Composite Steel System

Pre-decked Modular Steel Beams

- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Adaptable to any geometry

Precast Decked Girders

- Deck Bulb Tee
- Span lengths from 40 ft to 130 ft
- UT, WA, ID among states with DBT standards

- Double Tee – PCI NEXT beam
- Spans to 90 ft
- Low depth alternative
UHPC Joints in Bridge Deck

- Full moment transfer. No post tensioning required
- Only 6 in wide. High strength; low permeability

Longitudinal Joint

Integral Abutment

- Only one row of vertical piles
- Precast backwall - dowelled
- Fast construction

Semi-Integral Abutment

Suspended Backwall

- H piles or spread footings
- Fill pile pockets with SCC
- Easy fit-up in the field
Precast Piers

- Non-prestressed so contractor can self-perform precasting
- Fast erection using grouted splice couplers
- Deep foundation may be outside existing footprint

Grouted Splice Sleeve Couplers

Precast Approach Slab

- Flooded backfill
- Flowable fill under slab
- Exp joint can be moved to sleeper slab
ABC Erection Concepts for PBE

Erection Concept Drawings

1. Erection using conventional cranes.
2. Erection using ABC construction technologies adapted from long span construction

Erection Using Mobile Cranes

Short Single Span over Stream
Cranes selected for 90 Kip pick

Longer Span over Roadway
Weight up to 200 kips

Factors to Consider

- Weight of Module
- Pick Radius
- Crane Set Up Locations
- Ground Access / Barge / Causeway / Work Trestle
- Truck Access for Delivery
Erection with ABC Construction Technologies

- Use ABC construction technologies where ground access for cranes below the bridge may be limited.
- ABC technologies that allow construction from above:
  - Above Deck Driven Carriers
  - Launched Temporary Bridge
  - Transverse Gantry Frames
  - Longitudinal Gantry Frames

Above Deck Driven Carriers

- Allows fast rate of erection
- Rides on existing bridge or new bridge
- Ideal for bridges with many spans, long viaducts

Launched Temporary Bridge

- Sites with limited ground access or long spans
- Launched across to act as a “temporary bridge”
- Used to deliver the heavier modules without inducing large erection stresses.
Sample ABC Design Calculations

- Three design examples for prefabricated systems
  - Modular Decked Beams
  - Decked Precast Prestressed Girder
  - Precast Pier
- Stages for design are demonstrated
  - Prefabrication Stage (many support options)
  - Erection Stage (many lift options)
  - Final Stage (Modules are assembled on site)

Proposed LRFD Specs for ABC

- LRFD formatted design and construction specifications
- Address impediments in LRFD Specs to ABC implementation:
  - Loads and Load combinations
  - Construction load cases, Erection stresses
  - Design of connections
  - Design responsibility — EOR / Contractor's engineer
  - Prefabrication tolerances, quality, rideability
  - Assembly plans

Slide-In Bridge Construction

Traffic impacts within:
- Tier 1: 24 hours
- Tier 2: 3 days
ABC Toolkit: Components of Slide-In Construction Bridge Design

1. Permanent Bridge Design
   • Permanent bridge design must consider how the new bridge will be slid into place.
   • Strengthen local areas where the push/pull system will be attached (end diaphragms)
   • Consider flexural, shear effects on substructure from moving vertical load

2. Temp Support System (falsework)
   • Design must consider anticipated load effects applied by the sliding system.
   • Relative stiffness of permanent support structures (likely relatively stiff) versus stiffness of temporary support structures (likely relatively flexible).
   • Anticipated deflection / settlement of the temporary system & provisions for vertical adjustment
   • Attach the temp support to the permanent structure
3. Push / Pull System

- Adequate force to overcome frictional forces
- Hydraulic jacks can either push or pull the system.
- Pairs of opposing strand jacks or winches can be used
- System controls to ensure all components work together
- Displacement control during the slide to ensure that the ends of the superstructure move at the same rate
- Contingency planning in the event of equipment failure

Movement Systems

- Push/Pull hydraulic jacks
- Pulling with strand jacks / Power winch
4. Sliding Bearings

- Steel rollers or PTFE (teflon) sliding bearings can be used.
- PTFE bearings could be designed to remain as part of the permanent structure.
- PTFE also allows the use of an unguided system.
- Rollers are more costly than PTFE pads and are often used on bridge projects with larger load requirements.

Slide Bearings

- Roller Bearings
- PTFE Pads

5. Sliding Forces

- Coefficients of friction for PTFE bearings are given in the AASHTO LRFD Specifications.
- Static and dynamic coefficients of friction.
- Use a trial slide to verify friction values
- Rollers have lower friction values
- Jacks with capacity well in excess of friction.

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<th>Slide Mechanism</th>
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<td>Self-lubricated bearings</td>
<td>0.01 of Vertical Load</td>
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<tr>
<td>PTFE Pads</td>
<td>0.01 of Vertical Load</td>
</tr>
<tr>
<td>Rollers</td>
<td>0.01 of Vertical Load</td>
</tr>
</tbody>
</table>
Lateral Slide Demonstration Project
NY I-84 Twin Bridges

- 20 Hr closure
- Two weekend nights
- Sept 21, 2013
- Oct 19, 2013

20 Hr Lateral Slide
NY I-84 Twin Bridges

Substantial completion in 10 months
Bridge Location

- MacKay Bridge
- Macdonald Bridge

Original Bridge

- Designed by P. L. Pratley
- Built by Dominion Bridge Company Ltd. in 1955.
- Suspension bridge: Main span 1,446 ft., L=2,498 ft.
- Operated by Halifax Harbour Bridges

Roadway Deck

- Deck OK for strength but high maintenance.
- Suspended structure replacement - Entirely new suspended structure including hangers in 2016.
Scope

- Replace suspended bridge superstructure including hangers
- Strengthen towers and bents if necessary
- Traffic to be kept running
- Superstructure replacement allowed only during closures – night / weekend closures
- Full segment replacement

Typical Deck Cross Sections

EXISTING

NEW

Fabrication
Managing a Super Project - The Role of a Project Coordinator

New Deck Segment

Photo from Lion's Gate Bridge Deck Replacement

Existing Elements

- Cables inspected in 2010
- Main cables in good shape, with sufficient capacity
- Tower and bents – very good

How?

- Traffic to be kept running
- 10 ½ hour full closures at night
- Approximately 7 full weekend closures
- Single-lane closures at off-peak times
Typical Erection Gantry

Segment replacement in Halifax side span
- 16 deck segments to be in Halifax side span
- Over DND property

Turntable Erection Gantry
Halifax Side Span Segment Replacement

Halifax Side Span Segment Replacement

Increased Shipping Clearance
› Bridge deck jacked up following deck replacement
› Raising of deck 10 ft. at midspan; 1 ft. at towers
› Increase in shipping clearance 7 ft.
Erection Analysis
- Complex analysis; 700+ steps analyzed; iterative

Wind Engineering
- Halifax – hurricane zone
- High wind speeds => significant wind loads

Wind Engineering – Aeroelastic Models
When?
- RFP – December 2013
- Proposals received (ABC, FI, AV JV) - April 2014
- LNP, American Bridge Canada – June 2014
- Contract award – October 2014
- Erection start – expected August 2015
- Substantial completion – Sept/Oct 2016
Lateral Slide of Historic Bridge
In Washington State

Presented By: Kevin Dusenbery
Structures Lead Engineer, Jacobs

Project Overview

Appendix M1
Conceptual Plans
Washington State Department of Transportation

ATKINSON CONSTRUCTION
JACOBS
HARTCROUSER
Project Location

Historic Truss

Warren truss
Proposed Three Span Steel Plate Girder Bridge On Original Alignment

Three Span Steel Girder Bridge

Detour Bridge Layout
Pier 2 Transport Beam

Pier 2 Plan & Details

Pier 3 Plan & Elevation
Details

Equipment

Skid Track Type 5400
Translation Device (Push/Pull Unit)

Push Pull Unit

Teflon Pads
Liftoff!

Remove Exist. Pedestal and Cut Off Anchor Bolts

Bunking up
Set Down on Skid

Pier 3

Cutting the Anchor Bolts
Shackled lower to upper Bearings

Lift Complete

Placing Track
Skidder in Place

Lowered onto Skid

Bridge under way
Move Complete

Questions

Kevin Dusenberry, SE, Jacobs
Phone: (425) 990-6833
Email: Kevin.Dusenberry@Jacobs.com

Project Web Page:
http://www.wsdot.wa.gov/projects/sr167/puyallupriverbridge/
Boeing North Bridge: Lessons Learned in Accelerated Bridge Construction

Gregory A. Banks, Myles Parrish, Charles W. Spry

WSDOT ABC Workshop
April 2015

Project Overview - Location

• Located in Renton, WA

Project Overview – Site Layout
Project Overview - Function

Project Overview – Existing Bridge Condition

- Bridge Seismically Deficient
- Bridge is on critical path for production
- Damage or loss poses economic risk

Project Overview – Replacement Bridge General

- 3-Span Continuous (245-feet total length)
  - Main Span: 134'-0"  |  End Spans: 55'-6"
Prefabricated Bridge Elements
- Steel Plate Girders
- Full depth precast deck panels
- Columns and Crossbeams

Project Overview – Replacement Bridge
Steel Plate Girders

Project Overview – Replacement Bridge
Full Depth Precast Deck Panels
Project Overview – Replacement Bridge
Columns and Crossbeams

6'-6" Drilled Shafts
150-foot length

Project Overview – Replacement Bridge
Columns and Crossbeams

4'-0" Precast Columns

Project Overview – Replacement Bridge
Columns and Crossbeams

Stage 1 – Precast Crossbeam
Project Overview – Replacement Bridge
Columns and Crossbeams

Stage 2 – CIP
Crossbeam Infill

- Straight
  Pre-tensioning
- Draped
  Post-tensioning

Project Overview – Replacement Bridge
Connections

Column to Crossbeam
Column to Shaft
Why ABC?

- Schedule Savings
- Bridge on critical path for 737MAX rollout
- Prefabricated elements
  - Added float to the construction schedule
  - Reduced risks of weather impacts
  - Environmental benefits with reduced CIP concrete over salmon bearing waters
Construction Constraints/Schedule

1. EXISTING
2. EXISTING + TEMP
3. NEW BRIDGE + TEMP
4. NEW BRIDGE

Environmental
Construction Constraints/Schedule
Renton Airport Height Threshold

Construction – Change Proposal

• Slow Start-Up
  – Delayed Permits
  – Coordination (Airport requiring night work)
  – Late commissioning of temporary bridge
• Permit Adjustment
  – Allowed for large cofferdams
  – Allowed for falsework at Piers 2 & 3
  – Contractor submitted a no-cost change proposal to switch to CIP

Construction – Change Proposal

• Change Proposal Details
  – Safety Concerns
  – Quality Concerns
  – Schedule Concerns
Construction - Change Proposal

• Safety Concern:
  Setting of precast crossbeam

• Response:
  – Erection comparable to bridge girders
  – Develop a good work plan
  – Elevated CIP on-site construction of Piers
    would introduce it’s own risks

Construction - Change Proposal

• Quality Concern:
  Grouting, # Joints, Tolerances
Construction - Change Proposal

- Quality Concern:
  Grouting, # Joints, Tolerances

- Response:
  - Durable joints if follow specifications
  - Grouting mock-up recommended
  - Adequate tolerances

Construction - Change Proposal

- Schedule Concern:
  Night work with no time savings

- Response:
  - Several opportunities for time savings
  - Crane required regardless
Construction - Precast Deck Panels

• Precast Deck Construction Details
  – UHPC (Ultra High Performance Concrete)
  – Girder Fabrication and Panel Erection

Lessons Learned

• Understand Construction Constraints/Risks
• Cost Savings with Standards & Repetition
• Certified PCI Prefabricator Required?
• Required Equipment Size
Thank You.

Questions?

Design Examples

• Developed for the FHWA Technology Partnership Program
• Culminated in demonstration project completed by WSDOT.
• Marked excellent collaboration between Owner, Researchers, Designers, Precaster, and Contractor

Reports Available from FHWA – Highways for LIFE

http://www.fhwa.dot.gov/hfl/

• Final Report
• Appendices
  A. Design Specifications
  B. Design Example No. 1
  C. Design Example No. 2
• Testing Report – Spread Footings
• Testing Report – Drilled Shafts
Reports Available from FHWA – Highways for LIFE

- Design Specifications
  - Formatted in AASHTO Guide Spec Language
  - Address design with HfL bent details

- Construction Specifications
  - Material controls
  - Tolerance control
  - Recommendations for contract control

Example Resources – NCHRP
Precast Bridge Elements and Systems (PBES)

A challenge for ABC is development of PBES for higher seismic regions

Concept of “Technology Readiness Level”

1. Reference: NCHRP 698 – Red fill blocks = work done since report was published.
2. NCHRP 12-102 – Current project to address TRL 7, Design & Construction Guidelines
Additional Helpful Resources

TRB AFF10(3): Subcommittee for ABC
https://sites.google.com/site/trbaff103/home
Accelerated Bridge Construction - Challenges

1. Rapid on Site Construction - ABC
2. Cost Effective - CEBC
3. Tight Tolerance - TTBC
4. Aesthetic - AeBC
5. Safe - SBC
6. Standard of Care - SCBC
<table>
<thead>
<tr>
<th>Accelerated Bridge Construction - Challenges</th>
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<tr>
<td>1. Rapid on Site Construction</td>
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<td>2. Cost Effective</td>
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<td>3. Tight Tolerance</td>
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<tr>
<td>5. Safe</td>
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<tr>
<td>6. Standard of Care</td>
</tr>
<tr>
<td>7. Low Risk</td>
</tr>
<tr>
<td>8. Durable</td>
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</table>

Jim Guarre – BergerABAM – jim.guarre@abam.com – 206/431-2234
WSDOT ABC Workshop – April 1, 2015 – Tumwater, WA
National Perspective on ABC Implementation

Benjamin Beerman, P.E.
FHWA Resource Center

Washington DOT
April 1, 2015
ABC and PBES

EDC 1
2011-2012

EDC 2
2013-2014

EDC 3
2015-2016
Elements  

PBES  

Systems
Project Examples use PBES/ABC
- Contract Plans
- Specifications
- Bid Tabs
- Schedule
- Pictures
Deployment Activities

• Workshops

• Webinars

• Scanning Tours

• Project Reviews

• Project Showcases

• Regional Peer Exchanges

• Publications
EDC - Bridge

EDC 2
- GRS-IBS
- Lateral Slide

EDC 3
- UHPC

NEW

ABC
- Right of Way & Utilities
- Contracting Requirements
- Geotechnical Solutions
- EIS Programmatic Agreements
- Procurement Methods
- ABC Decision Making Tools
Webinar Training - FIU

www.abc-utc.edu
1) Extend Bridge Service Life
2) Assess Bridge Condition
3) Maintain and Enhance a Knowledgeable Workforce
4) Maintain and Enhance the AASHTO Specifications
5) **Accelerate Bridge Delivery and Construction**
6) Optimize Structural Systems
7) Model and Manage Information Intelligently
8) Contribute to National Policy
• **12-98**: Guidelines for PBES Tolerances and Dynamic Effects of Bridge Moves

• **12-102**: Development of an ABC Design and Construction Specification

• **12-105**: System Performance of ABC Connection in Moderate-to-High Seismic Regions
Formation of ABC Subcommittee
AFF10 General Structures – parent committee
AFF10(3) – Subcommittee for ABC

Chair: Ben Beerman, FHWA
Vice Chair: Mary Lou Ralls

www.trbaff103.com
TRB
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

www.TRBAFF103.com

Committee on General Structures (AFF10)
Subcommittee on Accelerated Bridge Construction (AFF10-3)

Approximately one-fourth of the Nation’s 600,000 bridges require rehabilitation, repair, or total replacement. The construction-related work used to address these needs can create significant impacts to the surrounding area including mobility, safety, and other social-economic related impacts. Throughout the U.S., owner agencies are realizing that the results of using ABC strategies not only helps to address onsite related constraints, but can also improve how a bridge program is delivered when used in a more routine, programmatic manner.

Scope: The TRB Accelerated Bridge Construction (ABC) Subcommittee supports research, technology transfer, and implementation to advance ABC technologies related to policy, planning, procurement, design, materials, construction and contracting. The objective of the subcommittee is to expand the knowledge and expertise to foster the implementation of ABC-related technologies.

Road Map:
The Subcommittee will:
1. Stay informed on the current state of practice/art.
2. Identify, prioritize, and prepare research needs statements.
3. Collaborate with State DOTs, FHWA, and AASHTO groups.
4. Support research projects in the areas of ABC.
5. Support technology transfer and implementation of research projects through workshops, paper, and poster sessions.

On behalf of TRB, we welcome you to join and participate with the members of this subcommittee.
Strategic Highway Research Program (SHRP2) Implementation

Web Search: SHRP2 R04
Implementation Awards

• (8) projects scattered around the county
  – Gila River Indian Reservation (Arizona)
  – California
  – Kentucky
  – Maine
  – Missouri
  – Rhode Island
  – Wisconsin
  – Michigan
What has been done?
850 bridge projects
Lateral Slide

Source Data from EDC 2 Baseline Profiles July 19, 2013
Paradigm Shift
old practices

PBES: Pile Lagging

PBES: Grouted Couplers

PBES: Pile Pockets
Paradigm Shift – standards

3-10-10-3 Typical Section

3-11-11-3 Typical Section

4-11-11-4 Typical Section
Paradigm Shift strategies
Other Reasons for PBES

Project Delivery Comparison by Phase
Measured in Months

Con v. Const.

ABC

Scoping | Design | Procurement | Construction
---|---|---|---
12 | 60 | 3 | 24
12 | 24 | 3 | 12

99
51
Opportunities for Growth/Improvement

As long as we are building bridges there will always be ABC.
Paradigm Shift – standards

3-10-10-3 TYPICAL SECTION

3-11-11-3 TYPICAL SECTION

4-11-11-4 TYPICAL SECTION
Paradigm Shift – standards
Connection Evolution!

Conventional Concrete

UHPC
UHPC connections - Adjacent Box Beam

- Full Moment/Shear transfer across the joint
- No membrane with overlay
- No composite deck
- No joint leakage

No. 4 rebar lap splice
CTDOT: I-84
2 bridges, 60 hours
7/2014

Every “S” in PBES

MNDOT: Hastings

8/2014

UTDOT: Layton Parkway
3rd Dimension, 8/2010

UTDOT: Sam White
2 Span Cont., 4/2011
VTrans: I-94 Hartford

ALDOT: Dothan

2015
PBES/ABC

Summer/2011

MassDOT: 93Fast 14

TNDOT: 40Fast 8
2015
Tappan Zee

PBES/ABC

Tappan Zee

NYDOT: $4B/ 2014
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<td>61.10</td>
<td>71.60</td>
<td>74.62</td>
<td>82.61</td>
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</table>
Thank You!

FHWA

Benjamin Beerman, P.E.
Back Up Slides
Resources - Summary

• ABC Project Exchange:

• PBES Webinar Training:
  – www.fhwa.dot.gov/everydaycounts/technology/bridges/pbeswebinartraining

• PBES Peer Exchanges:

• ABC/PBES Publications:
  – www.fhwa.dot.gov/bridge/prefab/pubs.cfm

• Ongoing monthly ABC webinars via FIU:
  – www.abc.fiu.edu

• SHRP2 R04 Product:

• PCI North East:
  – www.pcine.org/

• Utah DOT:

• TRB ABC Subcommittee AFF10(3):
  – https://sites.google.com/site/trbaff103

• MAP 21:
  – http://map21.transportation.org/Pages/MAP21Bill.aspx

• Innovative Funding Grant Program:
Viewpoints for Implementing ABC

- Some current ABC concepts are not new
  - Adjacent precast members in superstructure
- Other ABC concepts are new and developing
  - Precast substructures
    - Columns
    - Crossbeams
- Three primary challenges to implementation of precast bridge systems
  - Weight
  - Joints
  - Bridge geometry
Weight

- Girders up to about 270 k
- Shorter pieces are more problematic

Solutions:
- Controlled-density concrete
- Hollow sections
Joints

- Socket at base
- Column splices
- Column to crossbeam
- Girder flange connections
Geometry

- Vertical profile grade - precamber
- Horizontal curvature
- Slope for drainage or super