Innovative Bridge Designs for Rapid Renewal
ABC & State Experiences
2017, ABC Conference, Miami

Finn Hubbard, Fickett Structural Solutions
SHRP2 ABC/PBES
Subject Matter Expert
SHRP2 at a Glance

- **SHRP2 Solutions** – 63 products
- **Solution Development** – processes, software, testing procedures, and specifications
- **Field Testing** – refined in the field
- **Implementation** – 430 transportation projects; adopt as standard practice
- **SHRP2 Education Connection** – connecting next-generation professionals with next-generation innovations
What is SHRP2 R04?

- Provides state and local DOTs with a design toolkit for prefabricated bridge projects.
- Standardized approaches streamline the activities required to get bridge replacement systems designed, fabricated, and erected in less time, and **installed in hours or weeks, rather than months**.
- Standard design plans for foundation systems, substructure and superstructure systems, subsystems, and components that can be installed quickly with minimal traffic disruptions.
R04 Implementation Projects

- Through the Implementation Assistance Program, 8 states received funding and technical assistance to use the R04 product.
- SHRP2 Implementation Assistance Projects included:
  - Arizona: Gila River Indian Reservation
  - California: Fort Goff Creek
  - Kentucky: Stewarts Creek
  - Maine: Kittery Overpass
  - Missouri: Boone County
  - Rhode Island: Warren Avenue
  - Wisconsin: I-39/94
  - Michigan: Seney Wildlife Refuge
• A one day training class was assembled to introduce frontline employees at DOT’s to ABC in general and the SHRP2 R04 Toolkit in particular.
• This training was offered to the State DOT’s through the FHWA and AASHTO.
• A total of 16 states received the training last winter
• The R04 team is currently delivering 19 more training sessions
The 16 States Who Received the ABC Training

- Arkansas Delaware Florida Illinois
- Iowa Louisiana Michigan Montana
- Nebraska New Jersey New Mexico Pennsylvania
- South Carolina South Dakota Wisconsin
- Puerto Rico

- As can be seen here, states with larger populations along with states with large areas were interested in ABC
What the States Learned from the Training Class

• Overall introduction to the concept and practice of ABC
  – Why consider ABC?
  – What has changed that makes us interested in building bridges faster?
• Bridge movement technologies
  – PBES
  – Slide-in
  – SPMT
What the States Learned from the Training Class (Continued)

- What does the R04 Toolkit contain? How can it help?
- Lessons learned
  - Two demonstration projects
  - Eight implementation projects
- Costs and savings by implementing ABC
- Contractor interactions
- Tour of ABC projects from around the country
  - Information gathered from the three R04 Peer to Peer exchanges (42 states attended)
What the SHRP2 R04 Team Learned from the States

• Most states have tried an ABC project
• Only a few states have a fully developed ABC program
• States are working to develop a statewide ABC program
• States are interested in what others have done to develop their ABC program
• What is the level of effort to start up an ABC program?
• How do you “sell” ABC to upper management?
What the SHRP2 R04 Team Learned from the States

• What criteria should be used to evaluate ABC opportunities?
  – Safety aspects
  – Restricted construction window
  – Environmental issues
  – Mainline or local road

• What does ABC cost? Save?

• Traffic is a BIG ABC driver in some states

• Detour length is the main factor in some states

• How do I convince contractors that ABC is a good thing?
What the SHRP2 R04 Team Learned from the States

• What have been some of the “pit falls” on past ABC projects?
  – Survey
    • Measure twice, cut once comes to mind
  – Joints are critical
  – Pay attention during shop plan reviews
  – When using bar couplers, template, template, templates!
Global Observations on State Experiences with ABC

• Generally most states have had a good experience with their ABC projects
• Most states are in the same boat and we are all moving up the ABC learning curve together
• Costs continue to be a challenge to ABC
  – First projects are expensive
  – Cost do come down with experience and repetition
  – Look at the total project cost, not just bid prices
    • Traffic control
    • Project management
    • User costs
Questions?

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SHRP2 Overview
Innovative Bridge Designs for Rapid Renewal (R04) Using ABC/PBES

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SHRP2 ABC/PBES
Subject Matter Expert
SHRP2 Implementation:
INNOVATE.IMPLEMENT.IMPROVE.

$130 million
FUNDING ASSISTANCE

63
SHRP2 SOLUTIONS

430+
PROJECTS IMPLEMENTED

DOT
52 Recipients
MPO/LOCAL
30 Recipients
UNIVERSITY
10 Recipients
FEDERAL/TRIBAL
7 Recipients

230+
RENEWAL
100+
CAPACITY
90+
RELIABILITY
11
SAFETY
SHRP2 Implementation:
INNOVATE. IMPLEMENT. IMPROVE.

224,761
PARTICIPANTS ENGAGED

8,939
OUTREACH ACTIVITIES

14,961
HOURS TECHNICAL ASSISTANCE

TRAINING: 8,286
WORKSHOPS: 463
PEER EXCHANGES: 81
DEMOS: 62
SHOWCASES: 47
Focus Areas

**Safety**: Fostering safer driving through analysis of driver, roadway, and vehicle factors in crashes, near crashes, and ordinary driving

**Reliability**: Reducing congestion and creating more predictable travel times through better operations

**Capacity**: Planning and designing a highway system that offers minimum disruption and meets the environmental and economic needs of the community

**Renewal**: Rapid maintenance and repair of the deteriorating infrastructure using already-available resources, innovations, and technologies
EDC-2, Prefabricated Bridge Elements and Systems
EDC-2, Construction Manager/General Contractor
## EDC-3, Ultra High Performance Connections

### Current (December 2016)

- **Federal Lands Highway**
- **Puerto Rico**
- **US Virgin Islands**
- **Washington DC**

### Number of States in Various Implementation Stages

<table>
<thead>
<tr>
<th></th>
<th>Institutionalized</th>
<th>Assessment</th>
<th>Demonstration</th>
<th>Development</th>
<th>Not Implementing</th>
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</thead>
<tbody>
<tr>
<td><strong>Goal (December 2016)</strong></td>
<td>5</td>
<td>12</td>
<td>15</td>
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<td><strong>Current (December 2016)</strong></td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>13</td>
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<td><strong>Baseline (January 2015)</strong></td>
<td>11</td>
<td>10</td>
<td>26</td>
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</table>
Workshop Learning Outcomes

• **Understanding ABC**
  – What does it mean?
  – Why do we care?
  – How do we implement?

• **Knowledge of the SHRP2 R04 Toolkit**
  – How can it assist me?
  – What guidance does it contain?
Accelerated Bridge Construction (ABC)

ABC – refers to technologies, contract mechanisms, design templates, and rapid-time savings in bridge construction

- Reduces construction time and minimizes traffic impacts
- Decreases safety risks by minimizing contractor exposure to traffic
- Increases local contractor involvement through standardized approaches
- Reduces environmental impacts
- Saves money and time
What is SHRP2 R04?

• Provides state and local DOTs with a design toolkit for prefabricated bridge projects.

• Provides standardized approaches to streamline activities required to get bridge replacement systems designed, fabricated, and erected in less time, and installed in hours or weeks, rather than multiple months

• Provides standard design plans for foundation systems, substructure and superstructure systems, subsystems, and components that can be installed quickly with minimal traffic disruptions
• Research phase of R04 product included two pilot projects built using the SHRP2 R04 ABC Toolkit:
  – Keg Creek Bridge, Iowa Department of Transportation
  – I-84 EB & WB Bridges over Dingle Road, New York Department of Transportation
Through the Implementation Assistance Program, eight states received funding and technical assistance to use the R04 product.

SHRP2 Implementation Assistance Projects included:
- Arizona: Gila River Indian Reservation
- California: Fort Goff Creek
- Kentucky: Stewarts Creek
- Maine: Kittery Overpass
- Missouri: Boone County
- Rhode Island: Warren Avenue
- Wisconsin: I-39/94
- Michigan: Seney Wildlife Refuge
Questions?
SHRP2 Innovative Bridge Designs for Rapid Renewal

Introduction to ABC

ABC “Toolkit” for Designers

Finn Hubbard, Fickett Structural Solutions
SHRP2 ABC/PBES Implementation
Technical Lead
ABC is bridge construction that uses innovative, non-conventional approaches in planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges.
ABC Construction Methods

• Elements Assembled Onsite
• Slide In Bridge Construction (SIBC)
• Entire Super Structure moved in from a remote location (SPMT)
• Other methods?
Advantages of ABC

• Enhanced mobility - Reduces disruption to traffic and avoids congestion.
• Increased safety - Reduces exposure of workers and public to construction activities. Most of the construction is done at ground level.
• Reduced costs – Reduces owner costs, contractor risks, user delays, over time.
• Better quality control of precast elements
• Reduced environmental impacts
When to Use ABC

Emergency Replacement
At right, I-10 spans on Lake Pontchartrain after Hurricane Katrina

Planned Replacement
Process for Choosing ABC

- Successful use of ABC requires:
  - Careful evaluation of the requirements for the bridge,
  - Evaluation of site constraints, and
  - Review of total costs and benefits.
Gila River – Arizona
Good Locations for ABC???
### Test Case for ABC Selection

<table>
<thead>
<tr>
<th>Weight</th>
<th>Category</th>
<th>Decision-Making Item</th>
<th>Percentage</th>
<th>Points</th>
<th>Points Allocated</th>
<th>Scoring Guidance</th>
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<tbody>
<tr>
<td>%</td>
<td></td>
<td>Railroad over Bridge</td>
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<tr>
<td>17%</td>
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<td>Railroad under Bridge</td>
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<td>3</td>
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<td>2%</td>
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<td>Over Navigation (Channel that needs to remain open)</td>
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<td>8%</td>
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<td>Emergency Replacement?</td>
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<td>23%</td>
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<td>ADT and or ADT (Combined Construction Year ADT on and under bridge)</td>
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<tr>
<td></td>
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<td>Required Closures (Length of Delay to Traveling Public)</td>
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<td>6</td>
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<td>14%</td>
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<td>Are only Short Term Closures Allowable?</td>
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<tr>
<td>5%</td>
<td></td>
<td>Impact to Economy (Local business access, impact to manufacturing etc.)</td>
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<td>6</td>
<td></td>
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<tr>
<td>8%</td>
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<td>Construction Time (Restricted Construction Time)</td>
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<tr>
<td>3%</td>
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<td>Does ABC Mitigate a critical environmental impact or strategic environmental issue?</td>
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<td>5</td>
<td></td>
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<tr>
<td>3%</td>
<td></td>
<td>Compare Comprehensiveness Construction Costs (Compared conventional vs preparation)</td>
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<td>3</td>
<td></td>
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<tr>
<td>11%</td>
<td></td>
<td>Does ABC allow management of a particular risk?</td>
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<tr>
<td>12%</td>
<td></td>
<td>Economics of Scale (Repetition of components in a bridge or bridges in a project)</td>
<td>5</td>
<td>5</td>
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<td>Weather Limitations for conventional construction</td>
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<td>Use of Typical Standard Details (Complexity)</td>
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</table>

### Scoring Guidelines
- 6: Critical environmental impact
- 5: Mitigate several minor environmental issues
- 4: Mitigate a major environmental issue
- 3: Mitigate a minor environmental issue
- 2: Does not mitigate environmental issue
- 1: Critical pathological path of the total project
- 2: Major impact to critical path of the total project
- 1: Minor impact to critical path of the total project
- 3: No construction time restrictions
- 2: Minor construction time restrictions
- 1: Major construction time restrictions

### Notes
- Points allocated based on the severity and impact of each criterion.
- Scoring is subjective and may vary based on specific project requirements.

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*This table represents a simplified test case for ABC selection criteria with hypothetical scoring.*
Test Case for ABC Method

ABC Decision Flowchart

1. Identify a need or opportunity for ABC

2. ABC Rating 50+
   - Can project delivery be accelerated with ABC? (Yes/No)
   - Do the benefits of ABC outweigh any additional costs? (Yes/No)
   - Do the existing site conditions support an ABC approach? (Yes/No)

3. ABC Rating 49 to 21
   - Program initiative
   - Use conventional construction method
   - Alternate Contracting (FDM 11-90-92)

4. ABC Rating 0 to 20
   - Develop an ABC approach appropriate for the project

5. Goal to Minimize Bridge/Roadway Out-of-Service Time
   - Is there a location to build the bridge on-site? (Yes/No)
   - Is there a window of time available to close the bridge to move in a new bridge? (Yes/No)

6. Goal to Minimize Total Project Construction Window
   - Are the site conditions appropriate for PBES or GRS? (Yes/No)

7. Consider another ABC Alternative, Conventional Construction Method, or Alternate Contracting

8. Slide, SPMT, PBES, GRS-IBS
ABC Project Coordination

- Starts in planning
- Project Manager, Designer and Construction Engineer need to be on the same page
- Discuss the site constraints
- What is the best method?
  - PBES
  - Slide-in
  - SPMT
  - Other?
  - None
Other Factors: ABC Significantly Decreases Construction Impacts

- During peak construction season:
  - 20% of highways are under construction
  - More than 3,000 work zones.
  - Active work zone in 1 out of every 100 miles

- More than 40,000 people are injured each year in crashes in work zones.
- One work zone fatality every 8 hours – 3 per day
- One work zone injury every 9 minutes – 160 per day
Traffic and ABC

- We live in a different world from the one the interstate system was built in
- User delays are a real cost to society
- User delays include detour lengths
- ABC can dramatically help
Challenges of ABC

- Higher initial construction cost
- Considering user costs can be difficult/need standards
- Joint durability
- Connections approved for seismic regions
- Engineers need ABC standards/specifications/training
- ABC projects are perceived as more risky/less profitable
- Industry reluctance
- CIP culture/ contractors want to self-perform
ABC Example – Massachusetts
Massachusetts DOT replaced 14 bridges in 12 weekends!

- Used Prefabricated Bridge Elements and Systems (PBES)
Massachusetts DOT replaced 14 bridges in 12 weekends!

- Used Prefabricated Bridge Elements and Systems (PBES)
Massachusetts DOT replaced 14 bridges in 12 weekends!

- This is what caused the need to push hard and fast!
Fast 14 - Module Shipping

• Modules delivered in mass to stay on schedule
Fast 14 - Doing It Fast Means Lots of Equipment On Site
Fast 14 – Work Around the Clock

• Ten: 55-hour closures (each bridge was completed in less than 48 hours!)
The Toolkit contains the philosophy of ABC, movement technologies, and several completely worked out design examples in steel and concrete super structures and concrete substructures.
Elements vs. Systems
What are Prefabricated Elements?

• Element: Single structural component of a bridge:
  – Deck Element
  – Beam Element
  – Pier Element
  – Abutment and Wall Element
Prefabricalted Elements
Deck Elements

- Precast Deck Slab Panels:
  - Partial Depth
  - Full Depth
- Level of Compression
  - Post-Tensioning
- Ultra High Performance Concrete
  - Simplified Joints without Compression
Full Depth Precast Deck Panels
Diamond grinding is used to smooth deck after installation of the elements.

- Concrete cover in the elements needs to be thick enough to accommodate the grinding operation.
- Thin concrete overlays or asphalt can eliminate the need for grinding.
  - Dependent of the amount of differential alignment of the precast pieces.
Typical Decked Steel Girders

- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Lightweight system for ABC
Deck Bulb Tee Superstructure

85 foot span; 15 degree skew

NY Route 31
UHPC Prestressed/Post Tensioned Beams

Iowa???
Substructures and ABC

- May control the ABC schedule
- If possible do before ABC closure
- Precast abutments/footings
- Drilled shafts
- Precast piers
Drilled Shaft Outside Footprint
Complete Precast Piers

Conventional Pier

Straddle Bent
Precast Piers
Segmental Columns
Prefabricated Foundations

- Prefabricated footings
  - Size and weight issues
  - Precast sections with closure pours
- Prefabricated pile caps
  - Corrugated pipe pile pockets
- Prefabricated box caissons
  - Dewater for footing construction
Abutments on H Piles
Prefabricated Footings & Walls
Prefabricated Systems
Importance of Connections in ABC
Important Design Characteristics of PBES Connections

- Engineering characteristics for design:
  - Strong, Durable Material
  - Good Bond to Concrete
  - Good Bond to Rebar
  - Self Consolidating
  - Sustained Tensile Strength
  - Short Development Length
How UHPC Fits into ABC

• Benefits
  – Strong joint, short lap lengths of rebar
  – Watertight
  – Chloride resistant

• Drawbacks
  – Expensive material
  – Specialty sub contractor?
  – Non-familiarity of contractor/owner
UHPC Strength Gain

Compressive Strength Gain

[Graph showing compressive strength gain over age at test for different curing temperatures: Cure at 105°F, Cure at 73°F, and Cure at 50°F.]
UHPC Longitudinal Joints

6-inch joint using hairpin bars

6-inch joint using straight bars
UHPC Mixing and Placement – NYSDOT
Example
Link Slabs

- Another option for multi-span bridges
- Jointless, not continuous
  - Less complicated
  - Less Expensive
  - Great for prefabricated beam elements
- Used to accommodate the end rotations in the beams
Excellent Resource: FHWA ABC Connections Manual

Connection Details for Prefabricated Bridge Elements and Systems

Available at:
http://www.fhwa.dot.gov/bridge/prefab/if09010/
Precast Concrete Deck Panels
Open Shear Connector Pockets
Options for Connecting Deck Elements

• Closure pour with lapped reinforcement and rapid set concrete
• Small closure pour with UHPC
• Small closure pour with headed reinforcing bars and non-shrink grout
• Grouted shear key with transverse post-tensioning
• Match cast epoxied edges with transverse post-tensioning
Connections for Precast Systems:
• Grouted Splice Sleeve
• Grouted Post Tensioning ducts
• Grouted Cap Pockets (seismic)
Grouted Splice Sleeve Couplers

- Precast Concrete Column
- Column Reinforcing Bars
- Grout Sleeve
- Grout Inlet
- Grout Outlet
- Washer Seal
- Cast-in-Place Drilled Shaft (or Other Foundation)
Grouted Splice Sleeve Couplers
Grouted Splice Sleeve Couplers
Grouted Ducts for Dowels in Caps/Foundations
For Seismic Regions: Precast Bent Cap, Grouted Cap Pocket

Diagram:

- Precast Concrete Column
- Grout Tube
- Corrugated Metal Pipe
- Hollow Space
- Column (Wall Thickness)
- Grout Bed
- Dowels
- Cast-in-Place Drilled Shaft (or other foundation)
The concept of building all the bridge elements offline (where ROW is available) and then moving them into place in a few hours is a powerful ABC method to minimize traffic disruption.
Rapid Demolition Using Conventional Equipment
Rapid Demolition Using SPMTs

Existing bridge spans removed using SPMT.
ABC Methods, What to Choose?

• The construction site will lead you to the best ABC solution

• What are the constraints?
  – Interstate over local road
  – Local road over an Interstate
  – Bridge over a river
  – Open area around bridge site
  – Tight urban area
Bridge Moves with Self Propelled Modular Transporter (SPMTs)
Example: Barge-Mounted SPMTs

- Category 4 Hurricane Ivan struck the Pensacola area on September 16, 2004, damaging nearly a ¼ mile of the double span, I-10 concrete bridge over Escambia Bay.

- SPMTs on barges were used to transport 24 good spans from the east-bound lane to the west-bound lane.
Example: Utah Bridge Farm

Utah I–80 Bridges, State to 1300 East
SPMT Manuals

Manual for the Moving of Utah Bridges Using Self Propelled Modular Transporters (SPMTs)

May 30, 2008

Manual on Use of Self-Propelled Modular Transporters to Remove and Replace Bridges
June 2007

SPMT Resource Documents available here:
https://www.fhwa.dot.gov/bridge/abc/spmts.cfm
Erection Concepts For Bridge Replacement Using Cranes

Factors to Consider

- Weight of Module
- Pick Radius
- Crane Set Up Locations
- Ground Access/Barge/Causeway/Work Trestle
- Truck Access for Delivery
Crane Placement for Erection
Lateral Sliding of Bridges

- Sliding technique allows the projects to be built while minimizing disruption to traffic, accelerating construction, and reducing costs considerably.
- It can be used to slide the old bridge superstructure onto temporary supports to become the construction detour, leaving the old alignment open for new construction.
- Moving the bridge can be done by pushing, using pairs of hydraulic jacks pulled with strand jacks, or by cranes.
- The bridge is usually moved along a steel track.
Slide Track and Jacks
saved 2 million by NOT having to realign the interstate
Lateral Slide by Pulling With a Crane – Example

Green Bay, Wisconsin
Lateral Slide By Pulling with a Crane
Example: Slide Bearings
Example: Jacking After Roll-In
What’s in the R04 Toolkit for Designers?
Reminder:

• Focus on “workhorse” bridges.
• Complete bridges using prefabricated elements and modular systems.
• Contractor could self-perform much of the work.
• Simple to fabricate on site or in a plant and easy to erect using conventional cranes.
• Fast assembly in the field in 1 to 2 weeks.
• Durable connections/durable bridges.
Design Considerations for ABC Standards

- Eliminate deck joints at piers and abutments.
- Consider modular systems that do not require post-tensioning for assembly.
- Consider modular systems with integral wearing surfaces so that an overlay is not required.
- Provide extra $\frac{1}{2}$ inch for grinding for smooth riding surface and skid resistance.
- Consider modules that can be used in simple spans and in continuous spans.
Using the ABC Toolkit

- Review the ABC Standard Plans and Design Examples.
- General Information Sheets introduce the intent and scope of the ABC standard plans and details.
- Engineer of Record (EOR) should perform own ABC design calculations for the site using the examples as a guide.
- EOR to customize the standard plans for the site—span lengths/bridge width/module size/skew/foundations/etc.
• Lifting and Handling Stresses
• Shop Drawings and Assembly Plan
• Fabrication Tolerances
• Site Casting Requirements
• Geometry Control
• Mechanical Grouted Splices
• Element Sizes
• General Procedure for Installation of Modules
Sample Drawings from the ABC Toolkit

- Shows typical level of detail
- Plan sheets contain ABC specific details for routine bridges
- Guides the designer new to ABC on appropriate module configurations and connections
- Guidance on erection
Example
INTERIOR MODULE
REINFORCING DETAIL
(SHEAR STUDS OMITTED FOR CLARITY)
(L70 SHOWN; L40, L100 AND L130 SIMILAR)

TRANSVERSE CLOSURE POUR DETAIL
(TRANSVERSE REINFORCEMENT NOT SHOWN FOR CLARITY)

LONGITUDINAL CLOSURE POUR DETAIL
(LONGITUDINAL REINFORCEMENT NOT SHOWN FOR CLARITY)

Example
Example
ABC Standards for Modular Superstructures

- **Decked Steel Girders**
  - Decked Steel Girder Interior Module
  - Decked Steel Girder Exterior Module
  - Bearing and Connection Details

- **Decked Concrete Girders**
  - Prestressed Deck Bulb-Tee Interior Module
  - Prestressed Deck Bulb-Tee Exterior Module
  - Prestressed Double-Tee module
  - Bearing and Connection Details
ABC Standards for Modular Substructures

• **Abutments & Wing Walls**
  – Semi Integral Abutments
  – Integral Abutments
  – Wing walls
  – Pile Foundations and Spread Footings

• **Piers**
  – Precast Conventional Pier
  – Precast Straddle Bent
  – Drilled Shaft and Spread Footing Option
# Outline of ABC Standard Plans

<table>
<thead>
<tr>
<th>Standard Sheet Sets</th>
<th>Contents</th>
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<tr>
<td>G1 – G3</td>
<td>General Information Sheets</td>
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<tr>
<td>A1 – A12</td>
<td>Precast Abutments, Wing Walls, &amp; Approach Slabs</td>
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<tr>
<td>P1 – P9</td>
<td>Precast Complete Pier Systems</td>
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<td>S1 – S8</td>
<td>Decked Steel Girder Superstructures</td>
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<td>Decked Concrete Girder Superstructures</td>
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<tr>
<td>CC1 – CC32</td>
<td>ABC Erection Concepts</td>
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</table>
Span Ranges for Superstructures

- Simple/continuous spans from 40 ft. to 130 ft.
- Simple for DL; Continuous for LL; No Open Joints.
- Plans are grouped in the following span ranges:
  - 40 ft. to 70 ft.
  - 70 ft. to 100 ft.
  - 100 ft. to 130 ft.
- Spans to 130 ft. can usually be transported and erected in one piece at many sites.
- Weight < 200 Kips for erection
Modular Superstructure Systems

Deck Bulb Tees

Double Tees

Composite Steel System
Typical Decked Steel Girder Module Interior

- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Lightweight system for ABC
Precast Decked Girders

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

- Based on the PCI NEXT beam
- Spans to 90 ft
- Low depth alternative
Integral and Semi-Integral Bridges for Rapid Renewal

- They allow the joints to be moved beyond the bridge.
- Well suited for ABC.
- Close tolerances required when using expansion bearings, and joints are eliminated.
- The backwall is precast with the deck.
- Fast erection in 1 to 2 days.
- Economical.
Example: Iowa – Semi-Integral Abutment Suspended Backwall

- H piles or spread footings
- Fill pile pockets with SCC
- Easy fit-up
Integral Abutment

- Only one row of vertical piles
- Precast backwall - dowelled
- Fast construction
Questions
Procurement, Costs, Savings and ABC

“Total” Project Costs
Contractors and ABC

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SHRP2 ABC/PBES Implementation
Technical Lead
Total Project Cost = Construction Cost + User Cost
Understanding ABC Costs

• In general, bid prices for ABC are higher than conventional construction
• Bid prices are not the only cost parameter
• Owners need to be persuaded thru Cost-Benefit Analysis
Evaluating ABC Costs

\[ \sum \text{Project Cost} = \sum_{t=0}^{\text{Serve Life}} \left( \text{planning}, \text{design}, \text{procurement}, \text{construction}, \text{maintenance} \right)_{\text{cost}} \]
How Much Does ABC Cost?

It depends…..

• *How fast is fast*
  – Build a bridge in a weekend: Very expensive
  – Build a bridge in two weeks: Not too expensive
  – Build a bridge in a month: Can be the same price

• *Overtime pay*
  – Weekends, nights

• *Details*
  – Complex details tend to be more expensive

• *Site conditions*
  – Difficult sites can lead to higher costs

• *Equipment*
  – Specialized equipment is pricey
Risk Analysis

- Risk cost = Cost of failure * Probability of Occurrence
  - Known probabilities can be managed
  - Unknown probabilities are difficult to estimate
  - Probabilities will vary between different contractors
    - Size and experience of staff
    - Back-up equipment
    - This makes it hard to estimate during design
  - Example
    - Weekend Disincentive Clause = $100K
    - Probability of not finishing bridge = 10%
    - Risk factor = $100k * 0.10 = $10,000
How Can Owners Address Risk?

• Understand that incentives and disincentives come at a price
  – Pick incentives and disincentives that are commensurate with the needs
• Tight schedules come at a price
  – Consider relaxing the schedule if appropriate
    • If a week is workable, do not try and do in a day
How Can Owners Address Risk?

• Risk Analysis?
  – Difficult for owners to estimate probabilities
  – Engage a specialty construction schedule consultant
• Allow for value engineering
• Consider Alternative Technical Concepts (ATC)
• CMGC
  – Risk management is a big part of this procurement process
Other Ways To Reduce Costs

• Bid a Series of Similar Projects
  – Builds up contractor experience = lower risk
  – Provides more efficient use of specialized equipment
    ▪ If it is a “one of a kind” project, you may pay for the equipment in one project
    ▪ Similar to precast girder forms
How Do You Justify ABC?

• If it costs more, why do we do it?
  – Reduces user costs
    ▪ However, you can’t spend user costs
    ▪ Good PR for the agency
  – Improves Safety
    ▪ Workers and travelers
  – Provides Better Durability
    ▪ Prefabricated Elements
Contractors Bid

- What do contractors price?
  - Materials, labor, **risk**
- Contractors profit by doing/building things
- Self performance is important
  - Who does what matters
  - Do not like to use subcontractors if possible
- Comfortable with conventional construction
  - Means and methods
Benefits and Risks of ABC

Benefits
• Complete more projects in one season
• Increase profits from additional work
• Less exposure to traveling public, safety
• Incentives to open early
• Better prepared for emergency ABC work

Risks
• Liquidated damages
• Tight schedule
• Weather
• Subcontractors
• Worker fatigue
• Equipment breakdown
• Unknown territory
Contractor Lessons Learned

- Allow contractors to self perform when possible.
- Use local equipment
  - “Keep it simple” really works
- Involve the contracting community as early and often as possible in the ABC process.
- Contractors have good ideas – work with them
- **A good team is the best solution!**
Risk Mitigation Between Procurement Methods

- CM/GC Basics
- Risk Allocation
- Difference between D-B-B, D-B, and CM/CG
- CM/GC Shared Risk Approach
Owners, Designers, Contractors, and CMGC

- Why do owners like CMGC?
- Why do designers like CMGC?
- Why (most) contractors like CMGC?
- What happens if the total cost of the project is not agreed to by the team?
  - There is a simple solution
  - Rarely needed
Do Bid Prices Tell The Whole Story?

- The simple answer is **NO**
- We need to look at **TOTAL PROJECT COSTS**
  - This is the total cost to the agency to complete a project
    - Engineering costs
    - Right of way
    - Environmental permitting
    - Traffic management
    - Construction management
    - Maintenance
    - Safety costs: police, flaggers, etc.
Factoring Non-bid Costs In Decision Making

• Decision makers should use both bid costs and agency costs in decision making
• There is no one ABC decision-making solution
  – Some agencies need a simple process
  – Some need detailed processes
• Oregon Analytical Hierarchy Process
  – Sophisticated analysis approach
  – Includes agency costs and indirect costs
• Connecticut DOT process
  – Simplified approach to total project cost
– ABC Costs depend on many factors:
  • Speed of construction
  • Incentive/Disincentive Clauses
  • Local capabilities
  • Risk analysis
– Bid prices do not tell the whole story
  • Consider non-bid costs in ABC decision making
Innovative Bridge Designs for Rapid Renewal
SHRP2, R04
Case Studies and Lessons Learned

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Technical Lead
Next Generation Innovative Bridge Design Projects

• Eight projects scattered around the county
  – Arizona, Gila River Indian Reservation
  – California, Fort Goff Creek
  – Kentucky, Stewarts Creek
  – Maine, Kittery Overpass
  – Missouri, Boone County
  – Rhode Island, Warren Avenue
  – Wisconsin, I-39/90
  – Michigan, Seney National Wildlife Refuge
Gila River - Arizona

- Project Delivery – CMGC
- Construction Manager/General Contractor
  - Team the GRIC DOT with the designer and contractor
  - Allows maximum use of contractor’s means and methods
  - Owner intimately involved in process
  - Bridge slide project (SIBC)
  - Wide open site, good for slide in ABC
Fort Goff Creek, California

- Built in a remote location in Northern California
  - 90 minutes to nearest ready mix plant
  - Precast answers this quality issue well

- Lessons Learned
  - Allow time for all needed pre-approvals
  - Entire team must be on board with ABC approach and available
  - ABC allowed construction in one short season
Stewarts Creek, Kentucky

- Replaced 2 bridges using R04 ABC techniques.
- A + B bidding, (Cost plus time)
  - Shorten closure time
  - Total project only 38 days
- Galvanized and painted steel superstructure
- Galvanized deck rebar
- Super in 2 longitudinal pieces
- Preassembly worked great
Kittery Overpass, Maine

- Replaced aging concrete ridged frame bridge.
- Maximum closure time was 35 days, used 29
- Heavy tourist area
- Contractor redesigned precast abutment wall to footing connection, accepted by Maine DOT
- Northeast Extreme Tee Deck Beams (NEXT)
- Carbon fiber prestressing strands to be used
  - No corrosion issues with stand
  - Also used “Z” bar in beams
Kittery Overpass, Maine
Kittery Overpass, Maine
Lessons Learned, Kittery Overpass

- ABC works!
- Traffic interruptions was minimized
- The tourist season saw minimal effects
- Locals really got involved in the whole ABC process
- Local police suggested useful modifications to the traffic management plan
- Excellent local and state wide press
- A + B bidding was successfully used
Route B Bridge, Boone County, Missouri

• Replaced bridge on Route B over Loop 70 in Columbia, MO
• ABC and Geosynthetic Reinforced Soil Abutments (GRS)
• Lessons Learned:
  – Make sure modular block are available that meet the spec.
  – Anyone can build a GRS Abutment
  – Present new technology early to contractors
Warren Avenue, Rhode Island

- Replaced highly deteriorated Warren Ave Bridge in Providence
- Lessons learned:
  - Semi twin bridge took over 400 days to build
  - New bridge closed road to traffic for 21 days
  - Very happy locals!
Warren Avenue, Rhode Island
I-39/90, Wisconsin

- Replaced 5 bridges using accelerated precast pier technique.
- ABC applied to pier construction
  - Precast columns and caps on cast-in-place footings
- Five median piers between I-39 lanes
- Saved 3 weeks time per bridge
- Main ABC driver was safety
  - Less exposure of traffic to contractor
  - Less exposure of contractor to traffic
I-39/90, Wisconsin
Lessons Learned, Wisconsin

- The first precast ABC project was pricey
- Better price with second contract
- Price was the same as cast-in-place on third contract
Seney National Wildlife Refuge, Michigan

- Federal Lands Highway applied R04 Toolkit to Seney National Wildlife Refuge PBES project
- Single lane, three-span continuous concrete box beam bridge
- Piers/abutments built with precast pile caps
- Placed a concrete overlay on top of boxes
- Concrete rails cast on to boxes before beam erection
- Prefabrication will limit impacts in an environmentally sensitive area
Seney National Wildlife Refuge, Michigan
Michigan
Three R04 Showcases
Three Peer to Peer Exchanges

- Implementation projects, Showcases and Peer to Peer exchanges provided various lessons learned
Many Forms of ABC

- Multiple pieces assembled on site or off-site
- Slide in Bridge Construction (SIBC)
- Self Propelled Modular Transporters (SPMTs)
- Keep your toolkit open to all ideas when considering ABC
Contract Methods Vary

• Contracting methods can very depending on needs
  • Design, bid, build (Traditional)
  • Design, build (Less control)
  • Construction Manager/General Contractor (CMGC)
  • A + B, Cost plus time
Time Savings Considerations

- Determine need for speed (maximum closure time)
- SPMTs are very fast, but pricey.
- SIBC is a nice combination of speed and cost.
- If 14 to 21 days will work, assembling pre-built pieces is cost effective.
- Weigh cost for speed.
  - Choose the time line carefully!
Lessons Learned
(The Hard Way)

• Survey twice, make sure its right
• Need good concrete bond to UHPC
• Must use high quality joint grout material
  – Avoid maintenance issues down the road
  – UHPC has been a great step forward
• Double check all rebar clearances during shop drawing reviews
• If using rebar couplers in precast elements, templets, templets, templets!
Owner Lessons Learned

• “DOT’s need to be innovative to stay relevant.”
• Durable joints are a must to gain acceptance.
• A top-down team approach with real resources committed is critical.
• Cultural change from “we have always done it this way” is not easy.
• DOT’s can gain real political capital from ABC.
Concluding Thoughts

• Be open minded.
• Do not be afraid to experiment with the method and materials
• Seek designer and contractor input before AND after every job for improvements
• Expect great publicity from ABC projects
  – Let the public know what your doing and why it is special!
Questions?