SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Introduction and Overview of Innovative Bridge Designs for Rapid Renewal (R04) Using ABC/PBES

Finn Hubbard, Fish & Associates Inc.
SHRP2 ABC/PBES
Subject Matter Expert

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Accelerated Bridge Construction Tools & Resources

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Photos courtesy: UDOT, MDOT, ADOT, MassDOT

SHRP2 Resources on Innovative Bridge Designs for Rapid Renewal

Innovative Bridge Designs for Rapid Renewal (R04) AASHTO Product Website

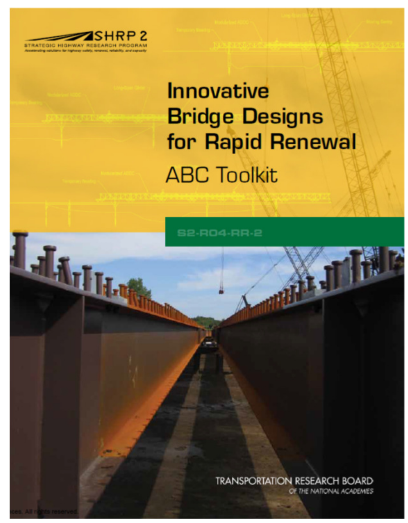
Tools and information related to this SHRP2 product, reports on how states are using R04 ABC Toolkit, training presentations, fact sheets, videos, and more.
http://shrp2.transportation.org/Pages/Bridge-Designs-for-Rapid-Renewal.aspx

Innovative Bridge Designs for Rapid Renewal FHWA Product Website

Information on R04 implementation activities from states, webinar recordings, case studies, and brochures.
www.fhwa.dot.gov/goshrp2/Solutions/Renewal/R04/Innovative_Bridge_Designs_for_Rapid_Renewal

Innovative Bridge Designs for Rapid Renewal ABC Toolkit

Published by the Transportation Research Board (TRB), the *ABC Toolkit* includes design standards and design examples for complete prefabricated bridge systems, and proposes specification language for accelerated bridge construction (ABC) systems, which adheres to the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design and Construction Specifications.
http://www.trb.org/Main/Blurbs/168046.aspx



Innovative Bridge Designs for Rapid Renewal Research Report

Published by the TRB, this report highlights the development of standardized approaches to designing and constructing bridge systems for rapid renewal.
www.trb.org/Main/Blurbs/167693.aspx

Accelerated Bridge Construction Websites

Federal Highway Administration Accelerated Bridge Construction Website

Contains FHWA's *Accelerated Bridge Construction Manual*, project planning tools, information on slide-in bridge construction, Prefabricated Bridge Elements and Systems, and ABC-related events.
www.fhwa.dot.gov/bridge/abc

Transportation Research Board Subcommittee on Accelerated Bridge Construction Website

The ABC Subcommittee supports research, technology transfer, and implementation to advance ABC technologies related to policy, planning, procurement, design, materials, construction, and contracting.
www.trbaff103.com/

AASHTO Subcommittee on Bridges and Structures (SCOBS) Website

Hosts Bridges and Structures Annual Meeting, offers guidelines and reports, and houses various technical committees.
http://bridges.transportation.org/

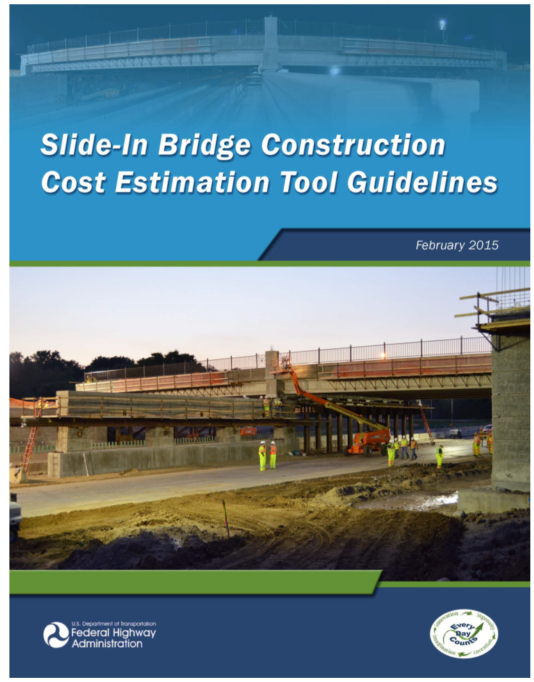
Accelerated Bridge Construction University Transportation Center Website

The ABC-UTC at Florida International University works to advance the frontier of ABC; transfer the state-of-the-art ABC knowledge to the profession; develop a next-generation ABC work force; and collaborate with the Federal Highway Administration (FHWA), AASHTO, and others to make ABC the best solution for the nation's aging bridge infrastructure.
https://abc-utc.fiu.edu/

Accelerated Bridge Construction Reports, Tools, and Manuals

Slide-in Bridge Construction Cost Estimation Tool Guidelines

Developed for FHWA's Every Day Counts Initiative, this publication provides a general guideline for state Departments of Transportation to estimate the cost of slide-in bridge construction (SIBC) for common bridge replacements.
http://www.fhwa.dot.gov/construction/sibc/pubs/costest/sibc_costest.pdf



Precast Prestressed Concrete Bridge Design Manual Third Edition

Describes the effective use of precast and precast, prestressed concrete components.
https://pci.imanuscript.com/ProductDetails.aspx?productID=117

PCI State-of-the-Art Report on Full-Depth Precast Concrete Bridge Deck Panels

A state-of-the-art guide for selecting, designing, detailing, and constructing precast full-depth deck panels for bridge construction.
https://pci.imanuscript.com/ProductDetails.aspx?productID=120

PCI State-of-the-Practice Report of Precast/Prestressed Adjacent Box Beam Bridges

Presents the state of the practice on adjacent precast pretensioned box beam bridges.
https://pci.imanuscript.com/ProductDetails.aspx?productID=121

PCI Curved Precast Concrete Bridges State-of-the-Art Report

Details the application of curved precast concrete bridge design, fabrication, construction techniques, and considerations through the study of twelve related projects and constitutes a state-of-the-art report on this topic.
https://pci.imanuscript.com/ProductDetails.aspx?productID=133

State ABC Manuals & Tools

Structures Design and Detailing Manual, Utah Department of Transportation

https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:1730,

ABC Decision Making and Economic Modeling Tool, Oregon Department of Transportation

http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2011/ABC.pdf

ABC Decision Making Tool, Wisconsin Department of Transportation

http://wisconsindot.gov/dtsdManuals/strct/manuals/bridge/ch7.pdf

Contacts: Jamal Elkaissi, FHWA, jamal.elkaissi@dot.gov; Patricia Bush, AASHTO, pbush@aashto.org

Quick SHRP2 Overview

- **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

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

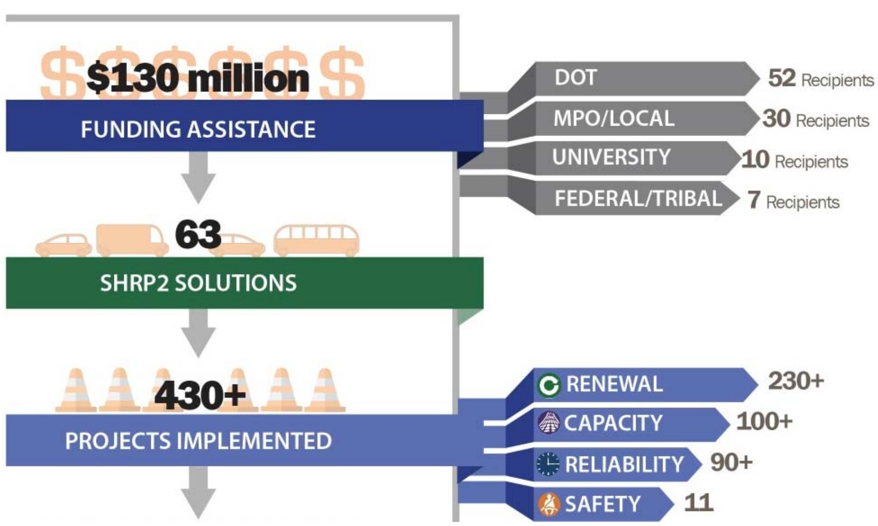
SHRP2 Implementation Assistance Program

- Designed to help State DOTs, MPOs, local agencies, and other interested organizations deploy SHRP2 Solutions

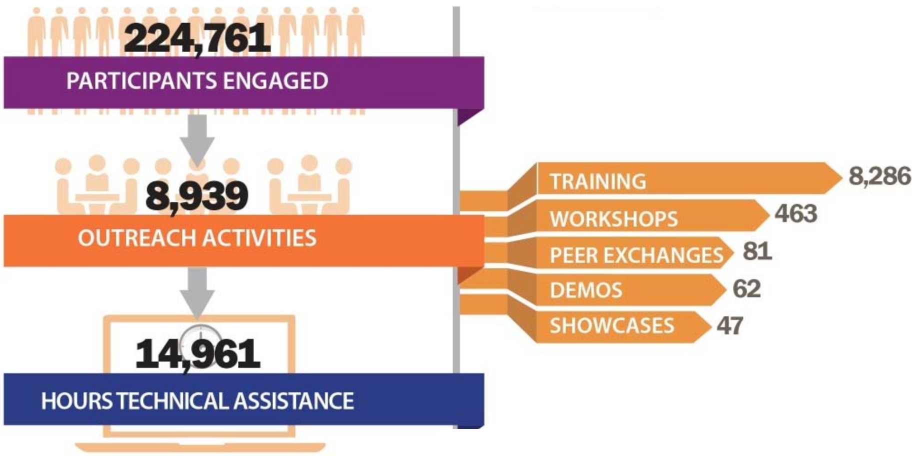
Proof of Concept Pilot	Lead Adopter Incentive	User Incentive
To evaluate product readiness.	To help offset costs associated with product implementation and risk mitigation.	To support implementation activities, such as conducting internal assessments, changing processes, and organizing peer exchanges.

12

SHRP2 Implementation: INNOVATE.IMPLEMENT.IMPROVE.



SHRP2 Implementation: INNOVATE.IMPLEMENT.IMPROVE.



America's Bridges Need Repair: SHRP2 is on the Job

Project Development

Innovative Bridge Designs for Rapid Renewal (R04)
Service Life Design for Bridges (R19A)
Service Limit State Design for Bridges (R19B)
Performance Specifications for Rapid Renewal (R07)

Construction

Innovative Bridge Designs for Rapid Renewal (R04)
GeoTechTools (R02)

Preservation

Nondestructive Testing for Concrete Bridge Decks (R06A)
Nondestructive Testing for Tunnel Linings (R06G)
Service Life Design for Bridges (R19A)

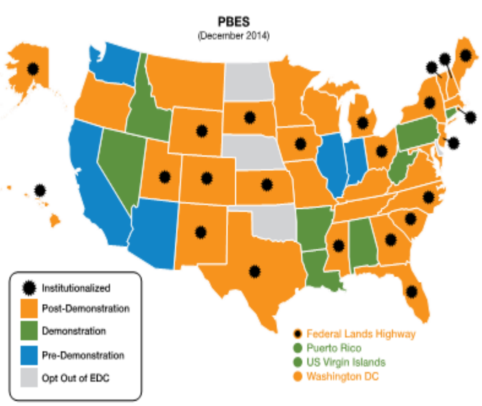
6

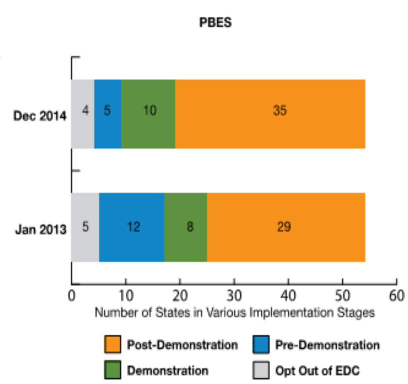
National IAP Deployment

~50 **IAP** Structures-**Related Projects Underway**

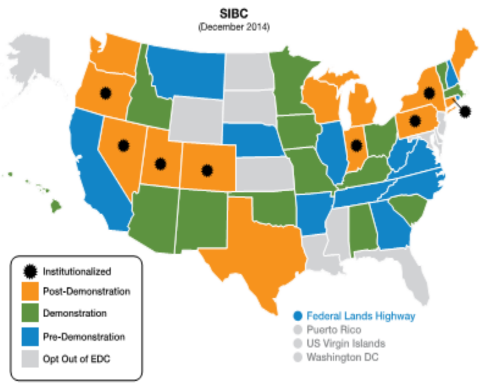
7

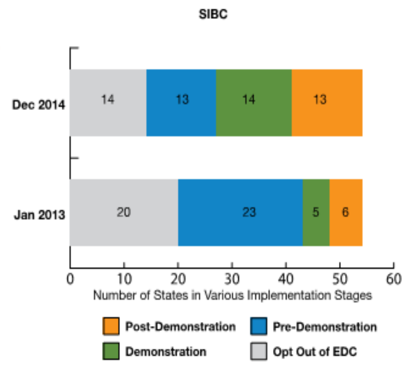
EDC-2, Prefabricated Bridge Elements and Systems



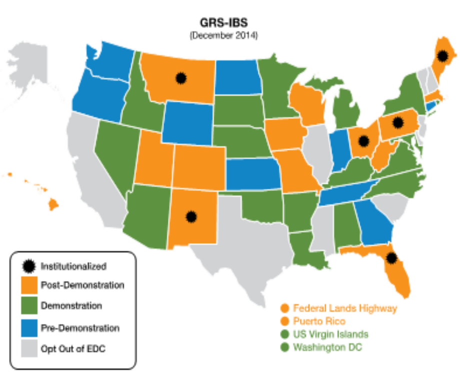


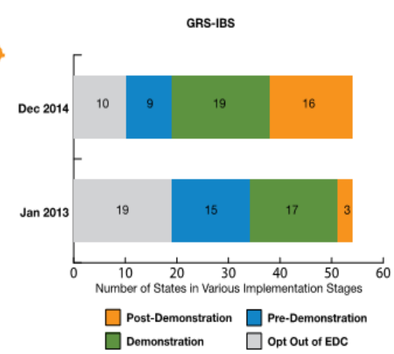
EDC-2, Slide-in Bridge Construction



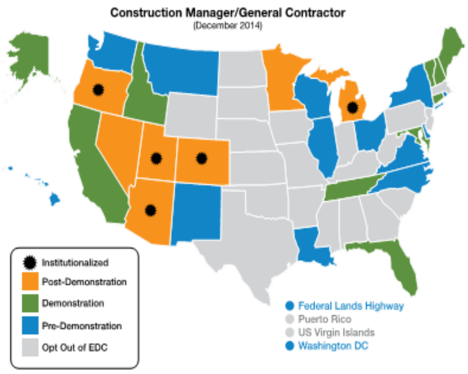


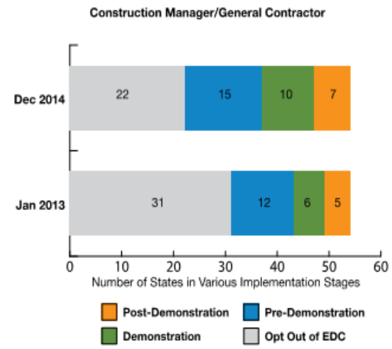
EDC-2, Geosynthetic Reinforced Soil-Integrated Bridge Systems



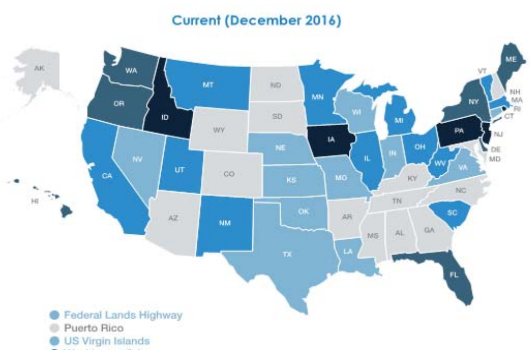


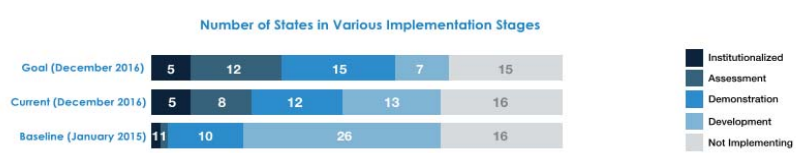
EDC-2, Construction Manager/ General Contractor





EDC-3, Ultra High Performance Connections





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?

13

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

14

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 days, rather than weeks or months**
- Provides standard design plans for foundation systems, substructure and superstructure systems, subsystems, and components that can be installed quickly with minimal traffic disruptions

15

R04 Pilot Projects

- 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

16

R04 Implementation Projects

- 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

17

Questions?

18




SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

SHRP2 *Innovative Bridge Designs for Rapid Renewal*

State Training Workshop
Toolkit: Lessons 1-6
2017/2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Today's Agenda

1. Introduction to Accelerated Bridge Construction (ABC)
2. Prefabricated Elements and Systems
3. Bridge Movement Technologies
4. ABC for Designers – Part 1
5. ABC for Designers – Part 2
6. ABC Examples: Keg Creek Project (Iowa) and I-84 (New York State DOT)

Lesson One: Introduction to Accelerated Bridge Construction (ABC)

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.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

ABC Construction Methods

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

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

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

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Why Will ABC Make a Difference?

- Reducing onsite construction time
  - 1 of 4 bridges in US needs rehab or replacement – how many in your state?
- Reducing mobility impact time
  - ABC should be considered when loss of a bridge during construction can exceed actual cost of structure itself.
  - Significant detours are required.

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.

When to Use ABC

Planned Replacement

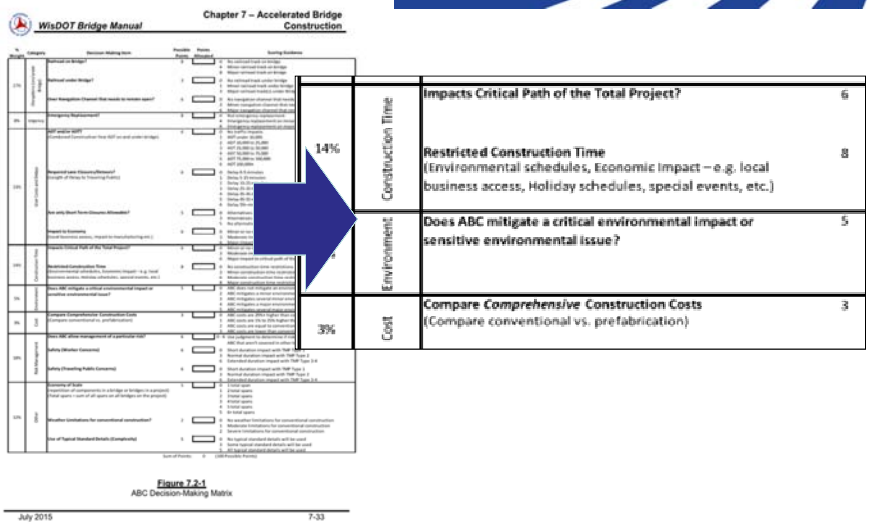
Emergency Replacement

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

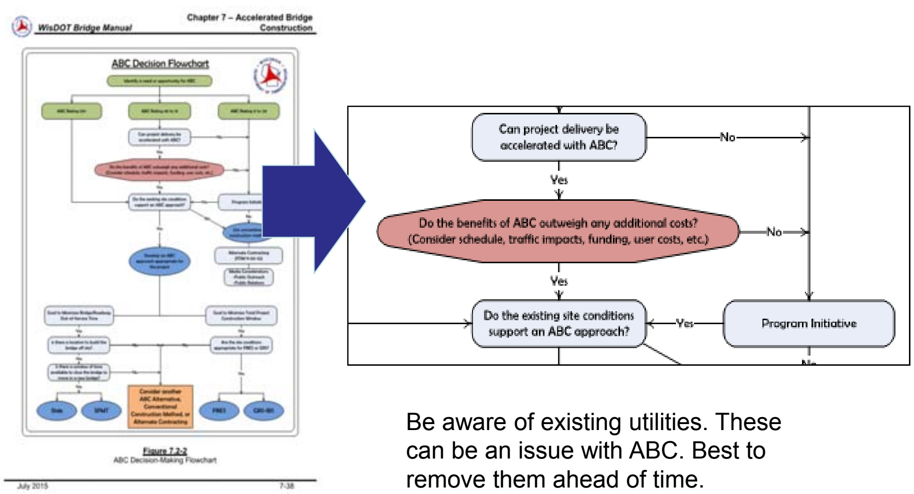
Planned vs Emergency ABC Projects

- Planned projects prepare contractors for the rigors of high speed emergency ABC projects
- Hard to beat experience of doing it fast when fast is required
- For example: I-85 Atlanta

Grading an ABC Opportunity



Flow Chart of ABC Selection Process



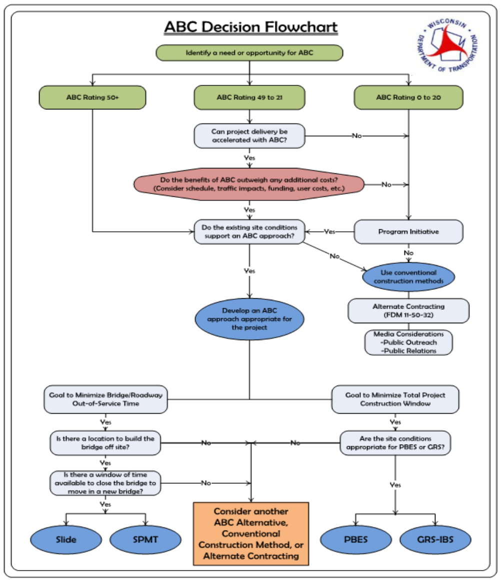
Be aware of existing utilities. These can be an issue with ABC. Best to remove them ahead of time.

Gila River - Arizona

Test Case for ABC Selection

% Weight	Category	Decision-Making Item	Possible Points	Points Allocated	Scoring Guidance
17%	Disruptions (on/under Bridge)	**Railroad on Bridge?**	8		0 No railroad track on bridge 4 Minor railroad track on bridge 8 Major railroad track on bridge
		Railroad under Bridge?	3		0 No railroad track under bridge 1 Minor railroad track under bridge 3 Major railroad track(s) under Bridge
		Over Navigation Channel that needs to remain open?	6		0 No navigation channel that needs to remain open 3 Minor navigation channel that needs to remain open 6 Major navigation channel that needs to remain open
8%	Urgency	**Emergency Replacement?**	8		0 Not emergency replacement 4 Emergency replacement on minor roadway 8 Emergency replacement on major roadway
23%	User Costs and Delays	**ADT and/or ADTT** (Combined Construction Year ADT on and under bridge)	6		0 No traffic impacts 1 ADT under 10,000 2 ADT 10,000 to 25,000 3 ADT 25,000 to 50,000 4 ADT 50,000 to 75,000 5 ADT 75,000 to 100,000 6 ADT 100,000+
		Required Lane Closures/Detours? (Length of Delay to Traveling Public)	6		0 Delay 0-5 minutes 1 Delay 5-15 minutes 2 Delay 15-25 minutes 3 Delay 25-35 minutes 4 Delay 35-45 minutes 5 Delay 45-55 minutes 6 Delay 55+ minutes
		Are only Short Term Closures Allowable?	5		0 Alternatives available for staged construction 3 Alternatives available for staged construction, but undesirable 5 No alternatives available for staged construction
		Impact to Economy (Local business access, impact to manufacturing etc.)	6		0 Minor or no impact to economy 3 Moderate impact to economy 6 Major impact to economy
14%	Construction Time	**Impacts Critical Path of the Total Project?**	6		0 Minor or no impact to critical path of the total project 3 Moderate impact to critical path of the total project 6 Major impact to critical path of the total project
		Restricted Construction Time (Environmental schedules, Economic Impact – e.g. local business access, Holiday schedules, special events, etc.)	8		0 No construction time restrictions 3 Minor construction time restrictions 6 Moderate construction time restrictions 8 Major construction time restrictions
5%	Environment	**Does ABC mitigate a critical environmental impact or sensitive environmental issue?**	5		0 ABC does not mitigate an environmental issue 2 ABC mitigates a minor environmental issue 3 ABC mitigates several minor environmental issues 4 ABC mitigates a major environmental issue 5 ABC mitigates several major environmental issues
3%	Cost	**Compare Comprehensive Construction Costs** (Compare conventional vs. prefabrication)	3		0 ABC costs are 25%+ higher than conventional costs 1 ABC costs are 5% to 25% higher than conventional costs 2 ABC costs are equal to conventional costs 3 ABC costs are lower than conventional costs
18%	Risk Management	**Does ABC allow management of a particular risk?**	6		0 - 6 Use judgment to determine if risks can be managed through ABC that aren't covered in other topics
		Safety (Worker Concerns)	6		0 Short duration impact with TMP Type 1 3 Normal duration impact with TMP Type 2 6 Extended duration impact with TMP Type 3-4
		Safety (Traveling Public Concerns)	6		0 Short duration impact with TMP Type 1 3 Normal duration impact with TMP Type 2 6 Extended duration impact with TMP Type 3-4
12%	Other	**Economy of Scale** (repetition of components in a bridge or bridges in a project) (Total spans = sum of all spans on all bridges on the project)	5		0 1 total span 1 2 total spans 2 3 total spans 3 4 total spans 4 5 total spans 5 6+ total spans
		Weather Limitations for conventional construction?	2		0 No weather limitations for conventional construction 1 Moderate limitations for conventional construction 2 Severe limitations for conventional construction
		Use of Typical Standard Details (Complexity)	5		0 No typical standard details will be used 3 Some typical standard details will be used 5 All typical standard details will be used

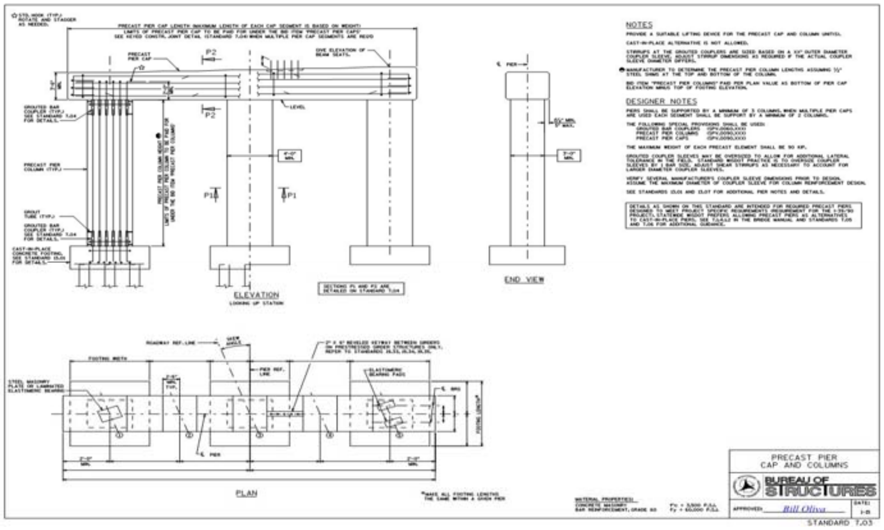
Test Case for ABC Method



Implementing a Statewide ABC Program

- Not a simple task
- Takes a real commitment at all levels of the organization
- Real resources (money, people) will be needed
- Utah, Policy, Manuals, Standards
  - Three consultant
  - Three full time employees
- Wisconsin DOT, Bill Oliva is a good resource
  - William.Oliva@dot.wi.gov

Implementing a Statewide ABC Program



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
  - 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 too
- ABC can dramatically help

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

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

Technical Challenges of ABC

- **Waterproof, long-lasting joints**
  - This has been an issue in the past
  - UHPC has improved this dramatically
- **Bridge Inspection Issues**
  - Need the joints to work
  - Nothing special about ABC (Other than joints)

Technical Challenges of ABC

- Tolerances
- Camber and Deflection
- Profile Adjustment
- Post-Tensioning
  - Secondary effects
  - Grout quality control

ABC Example – Massachusetts

I-93 Fast 14 Project

Massachusetts DOT replaced 14 bridges in 12 weekends!

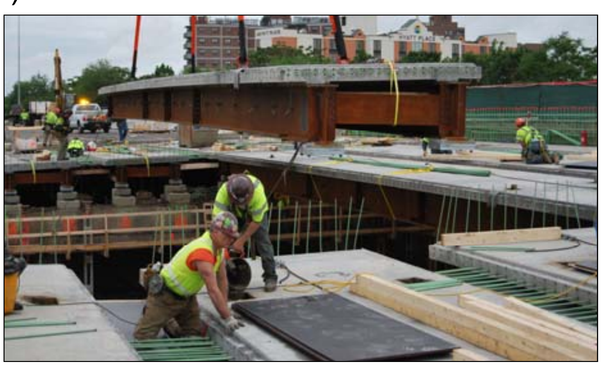
- Used Prefabricated Bridge Elements and Systems (PBES)

Lesson 1 Lesson 2 Lesson 3 Lesson 4 Lesson 5 Lesson 6

I-93 Fast 14 Project

Massachusetts DOT replaced 14 bridges in 12 weekends!

- Used Prefabricated Bridge Elements and Systems (PBES)



Lesson 1 Lesson 2 Lesson 3 Lesson 4 Lesson 5 Lesson 6

I-93 Fast 14 Project

Massachusetts DOT replaced 14 bridges in 12 weekends!

- This is what caused the need to push hard and fast!

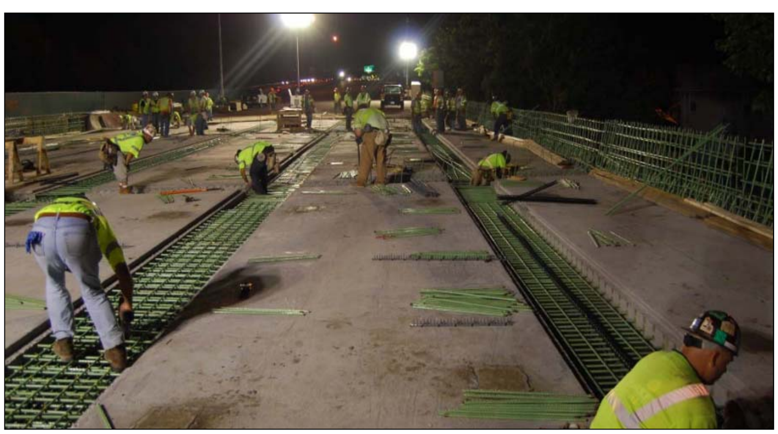
Fast 14 - Module Shipping

- 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!)



Questions

29

Lesson Two

1 Introduction to Accelerated Bridge Construction (ABC)

2 **Prefabricated Bridge Elements and Systems**

3 Bridge Movement Technologies

4 ABC for Designers – Part 1

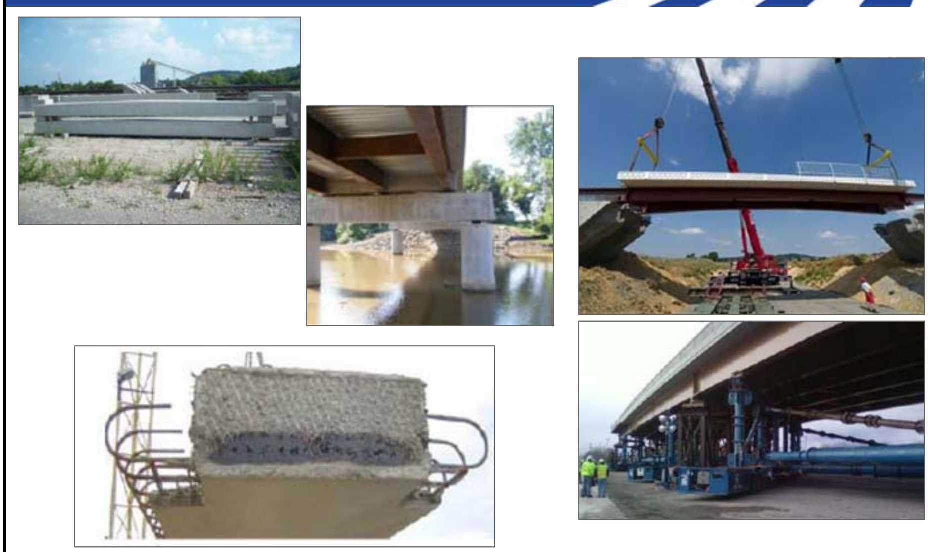
5 ABC for Designers – Part 2

6 ABC Examples: Keg Creek Project (Iowa) and I-84 (New York State DOT)

Prefabricated Elements and Systems

Prefabricated Bridge Elements and Systems (PBES) are structural components of a bridge that are built offsite or adjacent to the alignment, and include features that reduce the ***onsite construction*** **time** and ***mobility impact time*** that occurs from ***conventional construction*** methods.

Elements vs. Systems



Key Elements of Bridges Built Using PBES

- Completes construction in days (weekend) or in 1 to 2 weeks.
- Relies on extensive prefabrication of bridge elements.
- Uses ABC connection technologies for rapid assembly.
- Uses cranes/heavy-lifting equipment.
- Uses innovative contracting and procurement techniques to accelerate project delivery.

Benefits of Prefabrication

- Prefabrication bypasses restrictive sequential construction operations.
- Work can be done ahead of time and off the critical path.
- Risks posed by bad weather are reduced.
- Economies of scale produce significant benefits.
- Better quality construction is a result.

Benefits of Using Lightweight Concrete for PBES

- Reduces weight of precast elements
- Improves handling, shipping, and erection
- Provides longer spans, reduced substructure costs
  - All LWC (105 pcf)
    - Useable for any precast concrete element
    - Data not yet available for prestressed elements
  - Sand LWC (120 pcf)
    - Useable for any precast or prestressed concrete elements
  - NWC (145 pcf)

What are Prefabricated Elements?

- Element: Single structural component of a bridge:
  - Deck Element
  - Beam Element
  - Pier Element
  - Abutment and Wall Element

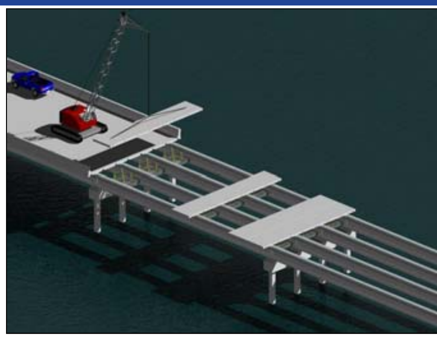
Prefabricated Elements

Deck Elements

- Precast Deck Slab Panels:
  - Partial Depth
  - Full Depth
- Level of Compression
  - Post-Tensioning
- Ultra High Performance Concrete
  - Simplified Joints without Compression

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Full Depth Precast Deck Panels



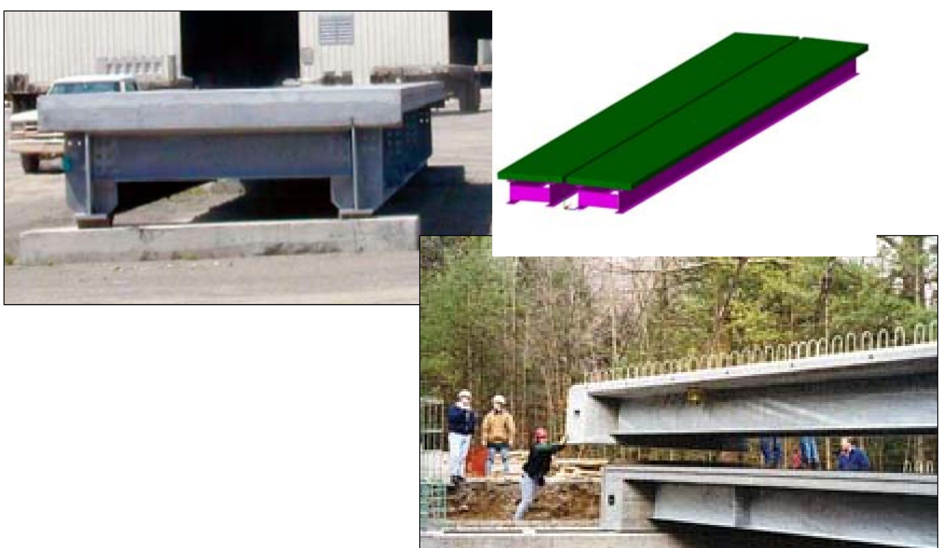
Precast Bridge Decks with Quality Riding Surfaces

- 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.

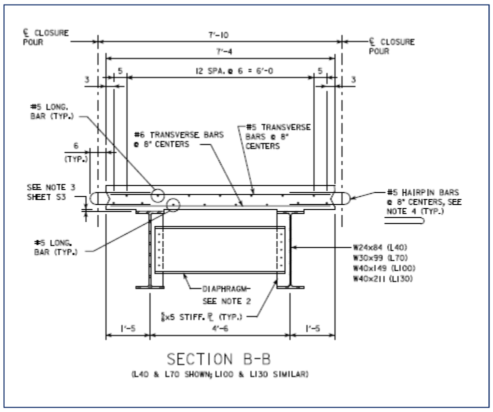
Deck Overlays for Precast Decks

- Concrete overlay will require additional time and/or bridge closures in order to place the overlay.
- For ABC projects, this can be accomplished on subsequent weekends after the bridge is reopened to traffic.
- Concrete overlays can be placed and cured in as little as three hours and provide low permeability and high bond strength.

Modular Composite Steel Elements

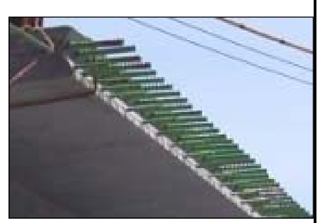


Typical Decked Steel Girders



- 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???

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

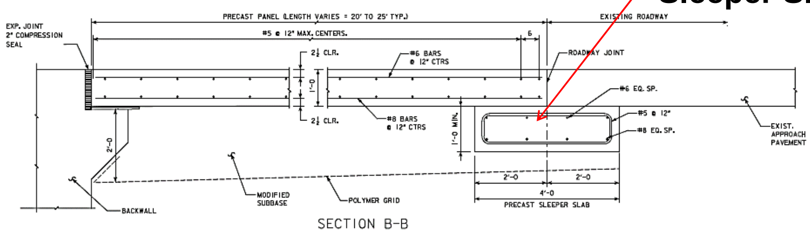
Precast Approach Slabs

- This precast approach pavement consists of doubly-reinforced concrete panels.
- Approach slab is supported on precast reinforced concrete sleeper slab.
- Expansion joint may be at backwall or at sleeper slab.
- Approach slab longitudinal joints are filled with UHPC.
- Flooded backfill placed in 1 foot layers.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Precast Approach Slab

Precast Sleeper Slab



- Flooded backfill
- Flowable fill under slab
- Expansion joint can be moved to sleeper slab

Lesson 1 | **Lesson 2** | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Substructures and ABC

- May control the ABC schedule
- If possible do before ABC closure
- Precast abutments/footings
- Drilled shafts
- Precast piers

Lesson 1 | **Lesson 2** | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Drilled Shaft Outside Footprint

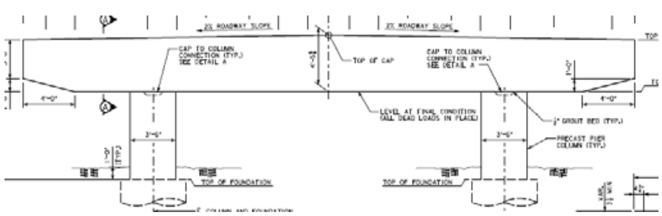
Auger Cast Piles for ABC

- Low overhead drilling with 3 foot-long auger flight
- Concrete injected through the hollow stem of augur
- Reinforcing cage inserted into wet concrete
- Reduced time

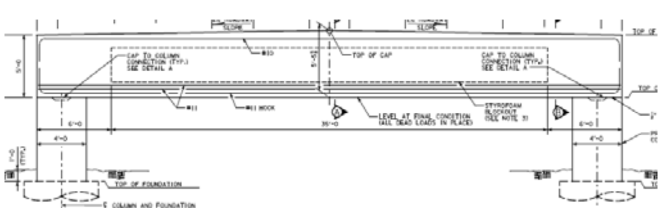
Micropiles for ABC

- Small drilling rig
- Simple load test
- Low impact to structures
- Low headroom

Complete Precast Piers



Conventional Pier



Straddle Bent

Precast Piers

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Segmental Columns

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

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

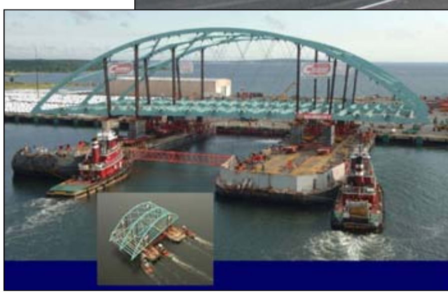
Abutments on H Piles

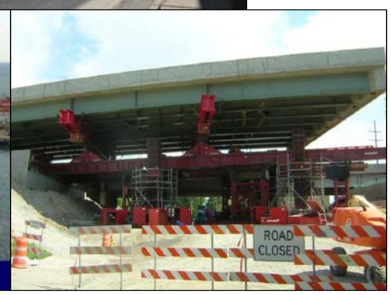
Prefabricated Footings & Walls

Skewed Bridges & ABC

- Skew of a bridge impacts use of PBES; however, it does not preclude it.
- Large skews can impact the complexity of the lifting and assembly.
- Complexity of prefabricated substructure elements and connections increases with skewed designs.
- Assembly time in the field will increase.

Prefabricated Systems





Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Importance of Connections in ABC

PBES Connections

- Connections have a significant influence on the overall ABC construction period.
- Goal is rapid field assembly and long-term durability of joints.
- Connections can affect the live-load distribution, seismic performance, and also the superstructure redundancy.
- Goal is flexural continuity emulating CIP construction.

Considerations for Selecting Connections for PBES

- Does the connection result in a rapid construction process?
- Does the connection transmit the forces between elements effectively?
- Is the connection durable?
- Is it cost effective and easy to construct?
- If a process or connection is proprietary, is there more than one supplier?

Options: ABC Connections

- Full moment connections between modular components can be used to emulate cast-in-place construction.
- Ultra High Performance Concrete (UHPC) or rapid set concrete can be used for longitudinal and transverse joints in superstructure.
- Self Consolidating Concrete (SCC) can be used for pile pockets and abutment to wing wall connections.

Options: Connections for ABC

- Cast-in-place concrete closure joints
  - Constructability; cure time; ride quality
- Post-tensioned grouted joints use the induced compression
  - Speed of assembly; durability
- Mechanical couplers
  - Seismic performance; fit-up
- Connections using rebar confinement

More Options: Connections for ABC

- Longitudinal and transverse joints between superstructure modules
- Grouted splice couplers in piers replace the typical lap splice
- Self Consolidating Concrete (SCC): Pile connections and abutment to wing wall connections
- Grouted cap pockets/grouted ducts for substructure connections (seismic)

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

What is UHPC?

- High-strength, ductile material formulated by combining Portland cement, silica fume, quartz flour, fine silica sand, high-range water reducer, water, and steel or organic fibers
- Also referred to as Liquid Steel

Compressive Strength:
20,000 to 32,000 psi

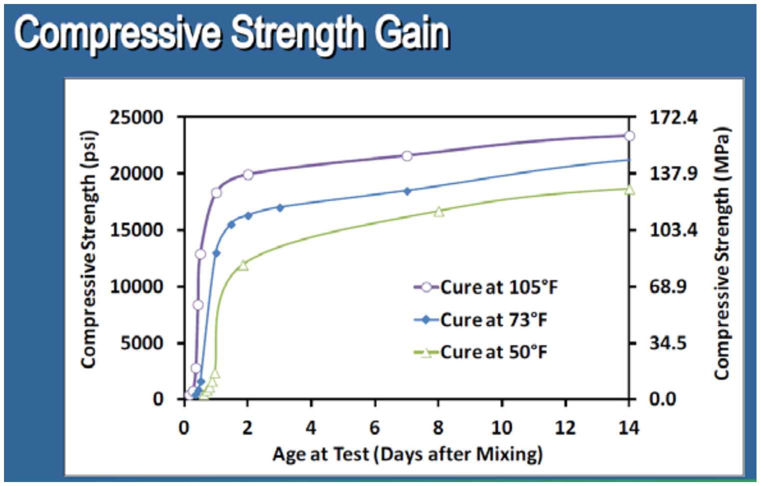
Flexural Strength:
3,000 to 7,000 psi

Ductility:
Greater capacity to deform and support flexural and tensile loads, even after initial cracking

Abrasion Resistance:
Similar to natural rock

Impermeability:
Almost no carbonation and penetration of chlorides

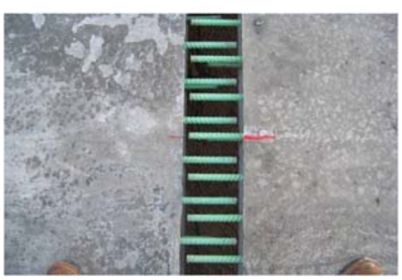
UHPC Strength Gain



Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

UHPC Longitudinal Joints

6-inch joint using hairpin bars

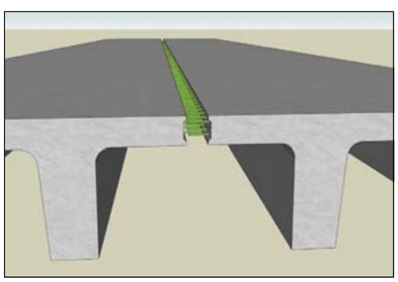


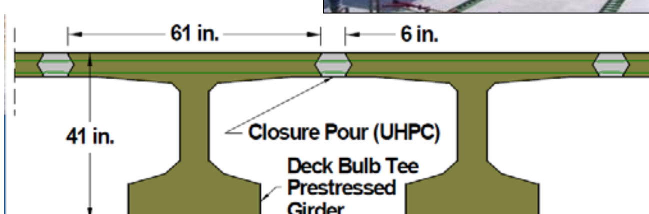
6-inch joint using straight bars

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

UHPC Mixing and Placement – NYSDOT Example

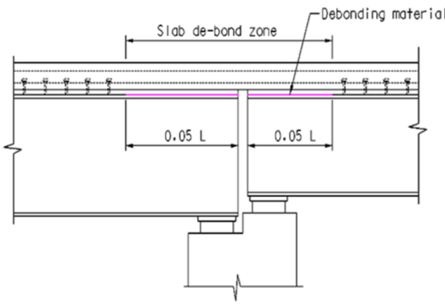
UHPC Connection of PC Beams



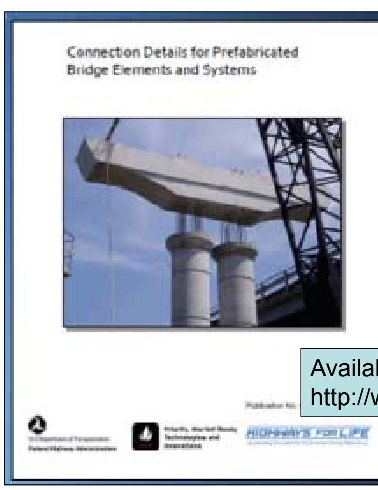


Link Slabs

- 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



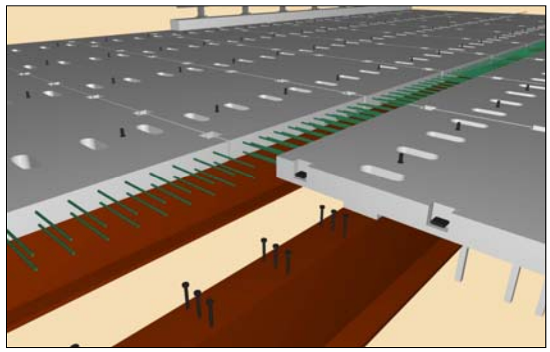
Excellent Resource: FHWA ABC Connections Manual



Available at:
http://www.fhwa.dot.gov/bridge/prefab/if09010/

Precast Deck Connections

- Composite Action:
  - Grouped Shear Studs
  - Grouted Pockets
  - Spacing



Precast Concrete Deck Panels
Open Shear Connector Pockets

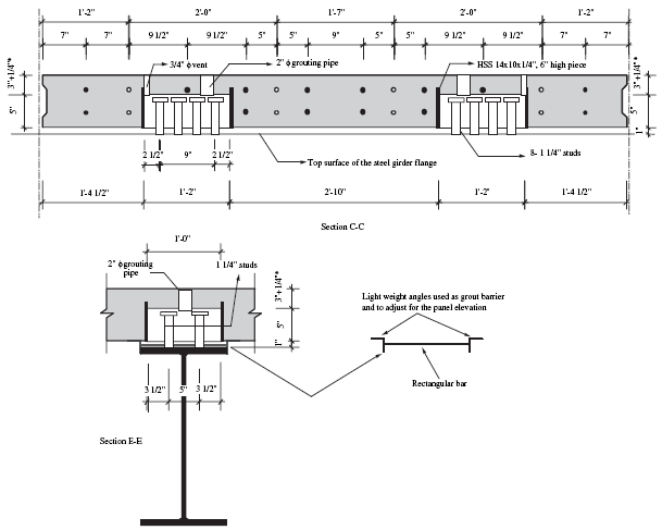
Options for Connecting Deck Elements

- 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

Post-Tensioned Connections in Decks

- Post-tensioning with grouted shear keys has been used in the distribution direction of precast deck slabs to transfer shear and some moments and keep joints in compression
- Prevents tension cracking under live load
- Improves durability
- LRFD requires an effective prestress force not less than 250 psi

Precast Concrete Deck Panels
Hidden Shear Connector Pockets

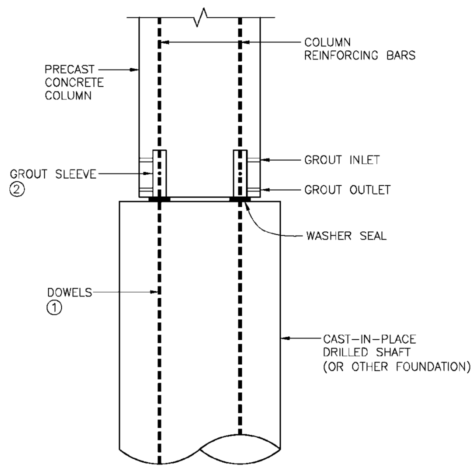


ABC Substructure Connections

Connections for Precast Systems:

- Grouted Splice Sleeve
- Grouted Post Tensioning ducts
- Grouted Cap Pockets (seismic)

Grouted Splice Sleeve Couplers

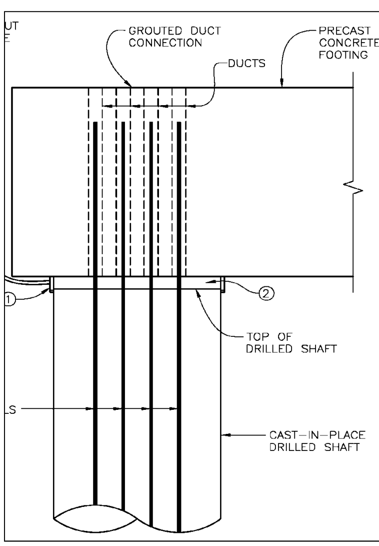


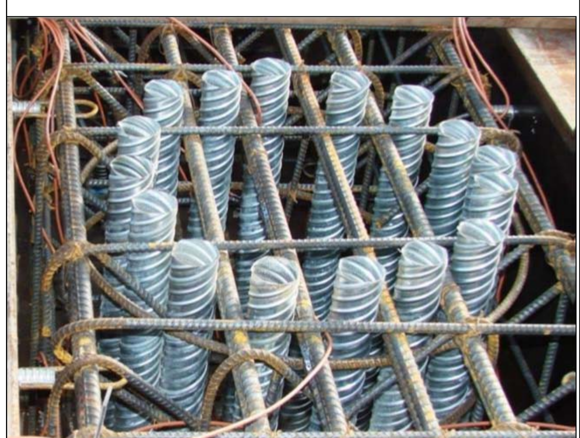
Grouted Splice Sleeve Couplers

Grouted Splice Sleeve Couplers

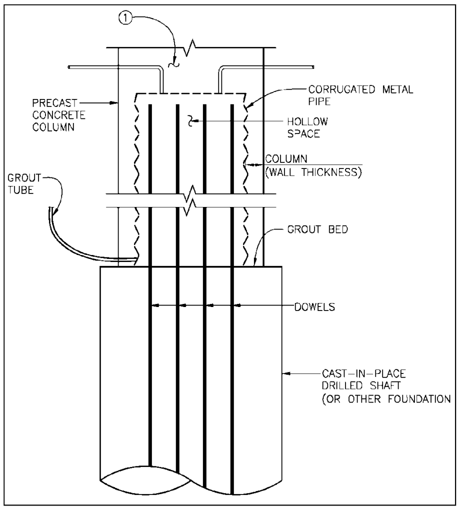
Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Grouted Ducts for Dowels in Caps/Foundations





For Seismic Regions: Precast Bent Cap, Grouted Cap Pocket



Connection Types for Seismic Regions

Column-to-Cap Connection Type	Seismic Design Category
Grouted Splice Sleeve[1]	A, B, C
Grouted Duct[2]	A, B, C, D
Cap Pocket[2]	A, B, C, D

1. NCHRP 12-74 has recommended use for limited-ductility applications only.
2. NCHRP 12-74 tested both a limited-ductility and a full-ductility cap pocket connection.

Other Connections for Seismic Performance

- Frame action in the transverse and longitudinal directions are the primary mechanism for resisting seismic loads.
- Engaging the superstructure and substructure in the longitudinal direction is necessary to mobilize the frame action.
- Proper seismic design of precast piers entails a detailed evaluation of the connection between superstructure and the supporting substructure system.

PBES Discussion and Participant Questions

Lesson Three

Bridge Movement Technologies

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

4500 South over I-215 (2007) Utah.
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

Benefits of Incremental Launching Precast Spans

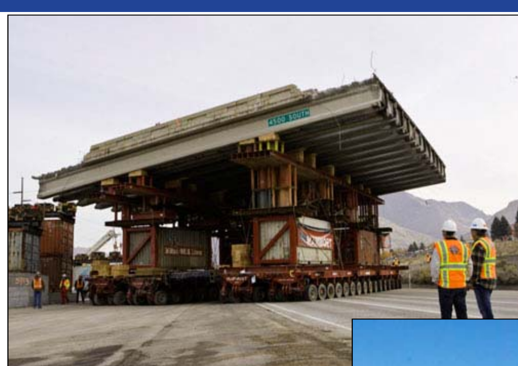
- Safety for workers
- Construction activities far from traffic
- Small casting yard with no additional right-of-way
- Height over canyon where falsework is impossible



Self Propelled Modular Transporter (SPMT)

- What is an SPMT?
- Large multi-axle platform
- Computer-operated
- Pivots 360 degrees
- Lifts, carries, sets large/heavy loads
- Moves at walking speed
- Each of the axles of the transporter moves independently

Bridge Moves with SPMTs



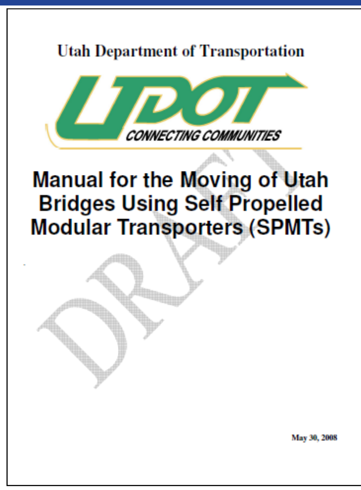
Example: Barge-Mounted SPMTs

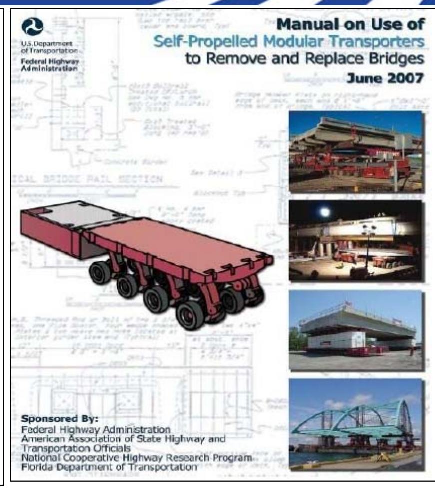
- Category 4 Hurricane Ivan struck the Pensacola area on September 16, 2004, damaging nearly a ¼ mile of the double span, I-10 concrete bridge over Escambia Bay.
- SPMTs on barges were used to transport 24 good spans from the east-bound lane to the west-bound lane.

Example: Utah Bridge Farm

Utah I–80 Bridges, State to 1300 East

SPMT Manuals





SPMT Resource Documents available here: https://www.fhwa.dot.gov/bridge/abc/spmts.cfm

Lesson 1 | Lesson 2 | **Lesson 3** | Lesson 4 | Lesson 5 | Lesson 6

Bridge Moves with Cranes

Lesson 1 | Lesson 2 | **Lesson 3** | Lesson 4 | Lesson 5 | Lesson 6

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

Lateral Slide Example: Nevada

I–15 West Mesquite Interchange, Mesquite, Nevada

Saved 2 million by NOT having to realign the interstate

Sliding Using Strand Jacks

- Strand jacks
- Measuring device
- P/t pumps

Lateral Slide by Pulling With a Crane – Example

Green Bay, Wisconsin

Lesson 1 | Lesson 2 | **Lesson 3** | Lesson 4 | Lesson 5 | Lesson 6

Lateral Slide By Pulling with a Crane

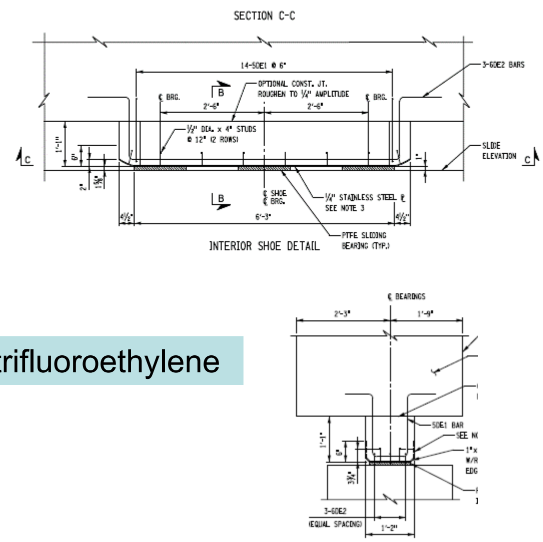
Example: Slide Bearings

Lesson 1 | Lesson 2 | **Lesson 3** | Lesson 4 | Lesson 5 | Lesson 6

Example: Jacking After Roll-In

Lesson 1 | Lesson 2 | **Lesson 3** | Lesson 4 | Lesson 5 | Lesson 6

Slide Shoe Detail Using PTFE Bearings



PTFE: Polytrifluoroethylene

Lesson Four

1. Introduction to Accelerated Bridge Construction (ABC)
2. Prefabricated Elements and Systems
3. Bridge Movement Technologies
4. **ABC for Designers – Part 1**
5. ABC for Designers – Part 2
6. ABC Examples: Keg Creek Project (Iowa) and I-84 (New York State DOT)

ABC for Designers – Part 1

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.

ABC Design Standards by State

- A single set of standard ABC designs would not be practical nationwide.
- These standards allow individual states to modify the details to fit their local needs and market conditions.
- Standardizing ABC systems may foster greater regional cooperation to accommodate regional practices and industry needs.

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 ½ inch for grinding for smooth riding surface and skid resistance.**
- Consider modules that can be used in simple spans and in continuous spans.

Lesson 1 | Lesson 2 | Lesson 3 | **Lesson 4** | Lesson 5 | Lesson 6

What's in the R04 Toolkit for Designers?

Using the ABC Toolkit

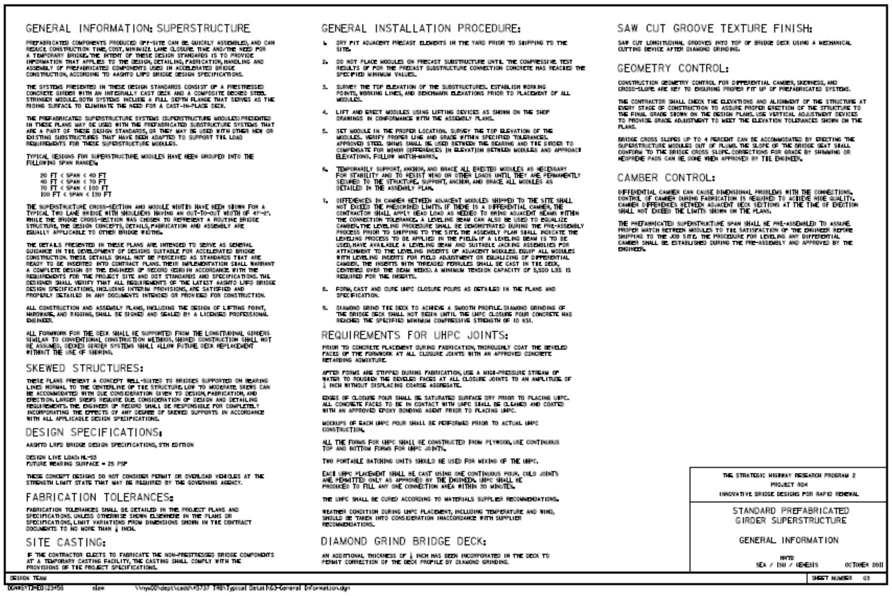
- Review the ABC Standard Plans and Design Examples.
- General Information Sheets introduce the intent and scope of the ABC standard plans and details.
- Engineer of Record (EOR) should perform own ABC design calculations for the site using the examples as a guide.
- EOR to customize the standard plans for the site—span lengths/bridge width/module size/skew/foundations/etc.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

General Information Sheet

- 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

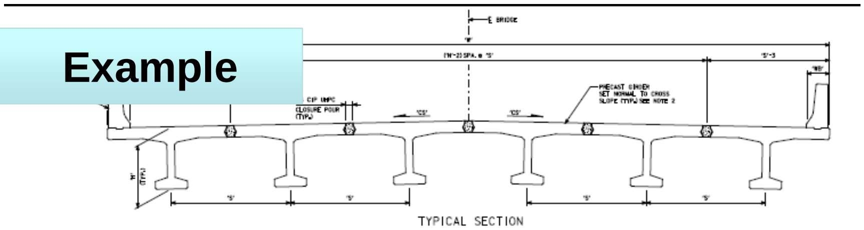
General Information Sheet

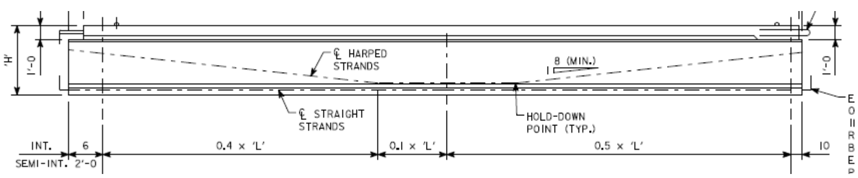


Sample Drawings from ABC Toolkit

- 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

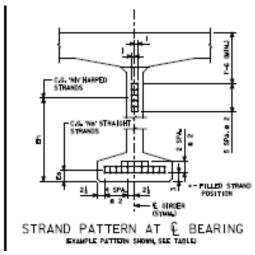
Example



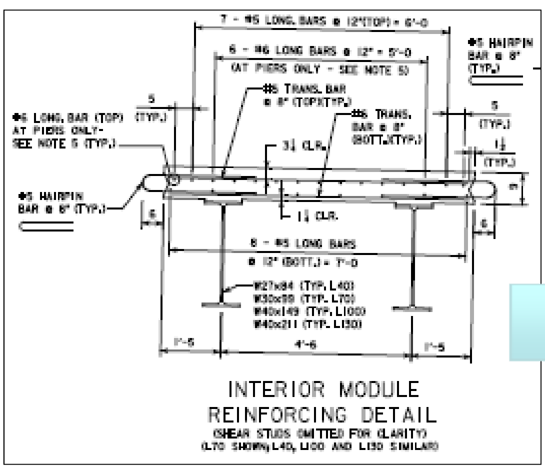


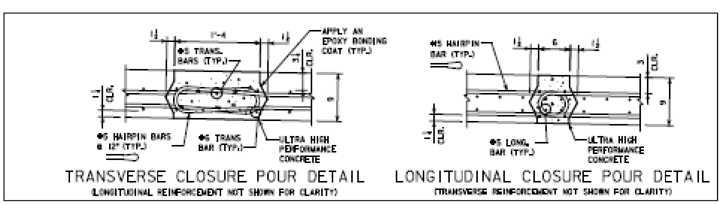
EXAMPLE STRAND LAYOUT - INTERIOR GIRDER

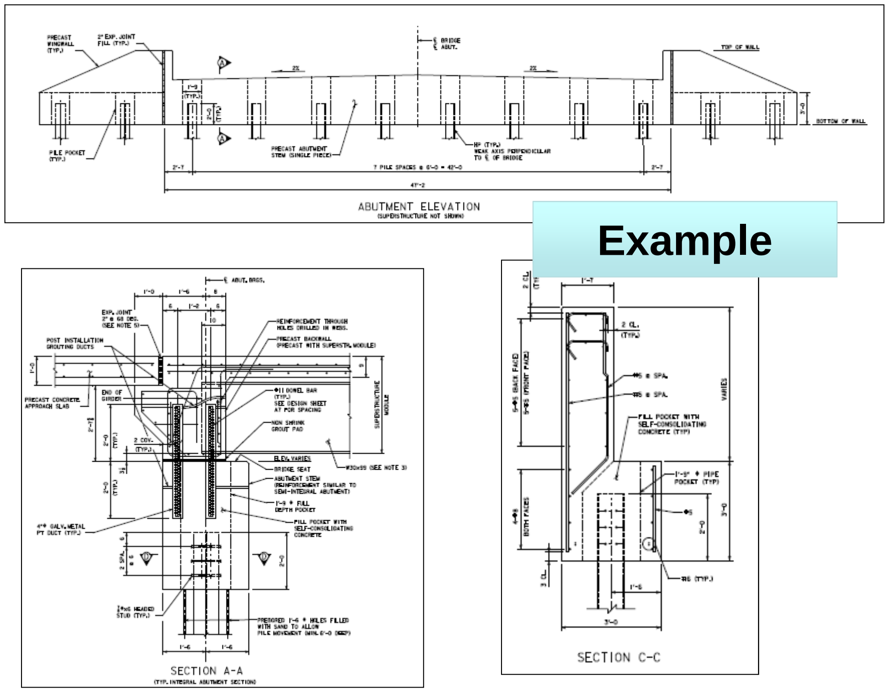
BEAM TYPE	'L' (FT)	'S' (FT)	f'c (KSI)	STRAND SIZE (IN)	STRAIGHT 'Ns'	STRAIGHT 'Es' (IN)	HARPED 'Nh'	HARPED 'Eh' (IN)	TOTAL 'N'	TOTAL 'E' (BRG.) (IN)	TOTAL 'E' (MID.) (IN)
DBT42	40	5	8	0.5	6	3.00	4	23.00	10	11.00	3.80
		8	8	0.5	6	3.00	6	22.00	12	12.50	4.00
	70	5	8	0.5	12	3.33	10	20.00	22	10.91	4.09
		8	8	0.5	16	3.75	14	18.00	30	10.40	4.33
DBT48	70	5	8	0.5	10	3.00	10	26.00	20	14.50	4.00
		8	8	0.5	14	3.57	14	24.00	28	13.79	4.29
	100	5	8	0.6	14	3.57	14	24.00	28	13.79	4.29
		7	8	0.6	16	3.75	16	23.00	32	13.38	4.38
DBT60	100	5	8	0.6	12	3.33	10	38.00	22	19.09	4.09
		8	8	0.6	14	3.57	14	36.00	28	19.79	4.29
	130	5	10	0.6	16	3.75	16	35.00	32	19.38	4.38
		7	10	0.6	24	4.50	16	35.00	40	16.70	4.70



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

Lesson 1 | Lesson 2 | Lesson 3 | **Lesson 4** | Lesson 5 | Lesson 6

Outline of ABC Standard Plans

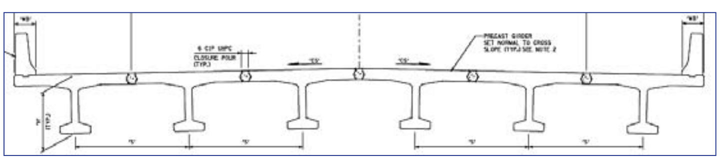
Standard Sheet Sets	Contents
G1 – G3	General Information Sheets
A1 – A12	Precast Abutments, Wing Walls, & Approach Slabs
P1 – P9	Precast Complete Pier Systems
S1 – S8	Decked Steel Girder Superstructures
C1 – C12	Decked Concrete Girder Superstructures
CC1 – CC32	ABC Erection Concepts

Lesson 1 | Lesson 2 | Lesson 3 | **Lesson 4** | Lesson 5 | Lesson 6

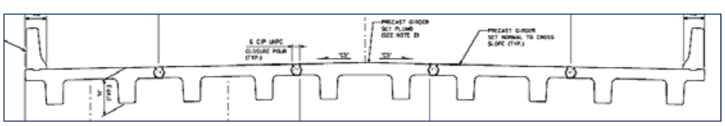
Span Ranges for Superstructures

- 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

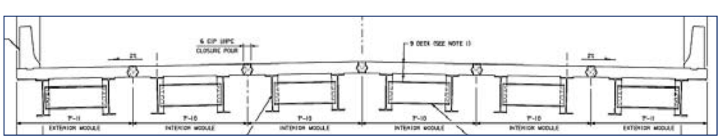
Modular Superstructure Systems



Deck Bulb Tees



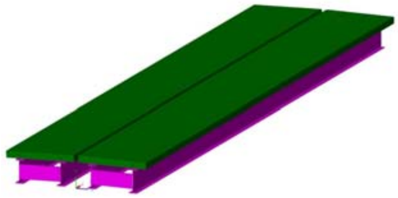
Double Tees

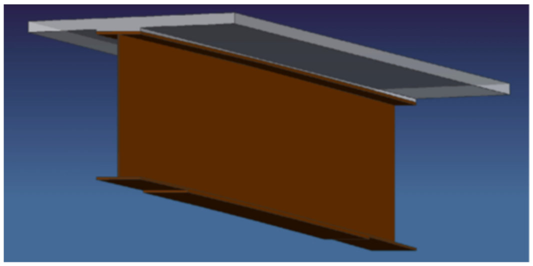


Composite Steel System

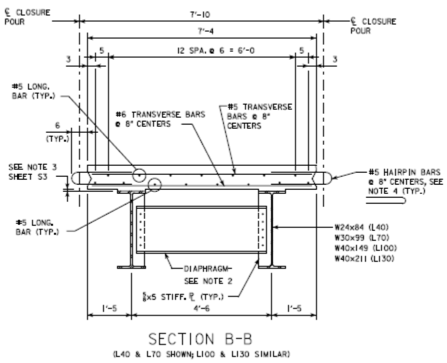
Pre-Decked Steel Elements

- Decked steel girders
  - Traditional girder
  - Sub-deck or partial deck top flange
  - Analogous to a bulb tee



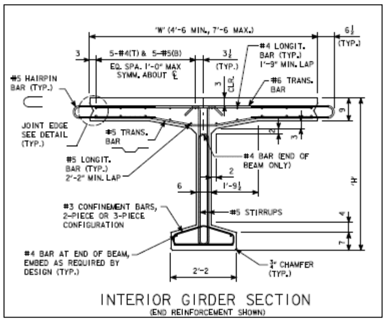


Typical Decked Steel Girder Module Interior

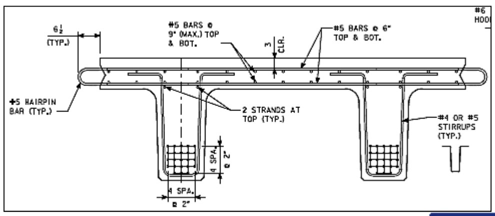


- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Lightweight system for ABC

Precast Decked Girders

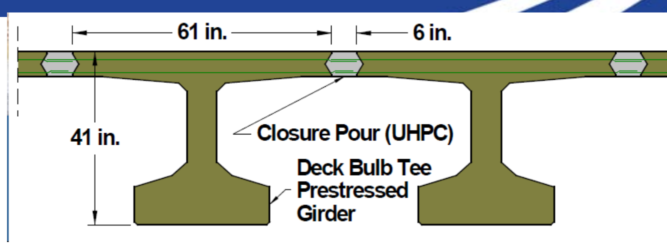


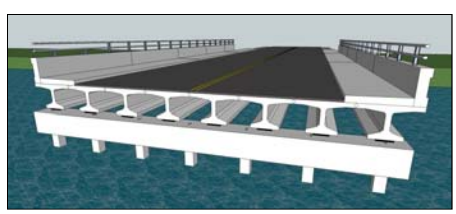
- Deck Bulb Tee
- Span lengths from 40 ft to 130 ft
- UT, WA, ID among states with DBT standards



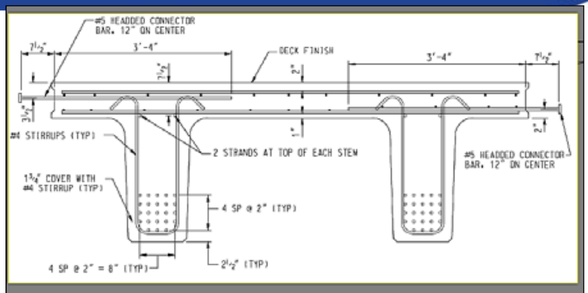
- Based on the PCI NEXT beam
- Spans to 90 ft
- Low depth alternative

Example: NYSDOT Decked Bulb-T Girders





NEXT Beam



- Depths: 24 to 36 inches
- Widths: 8 to 12 feet
- Spans to 90 feet

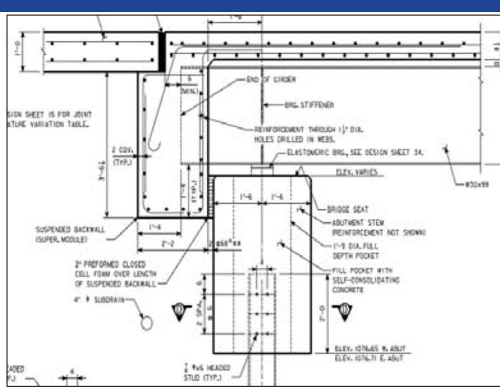
- Rapid installation
- Accommodate utilities
- Shallow depth—improved underclearance

Camber Leveling Using a Strongback

Integral and Semi-Integral Bridges for Rapid Renewal

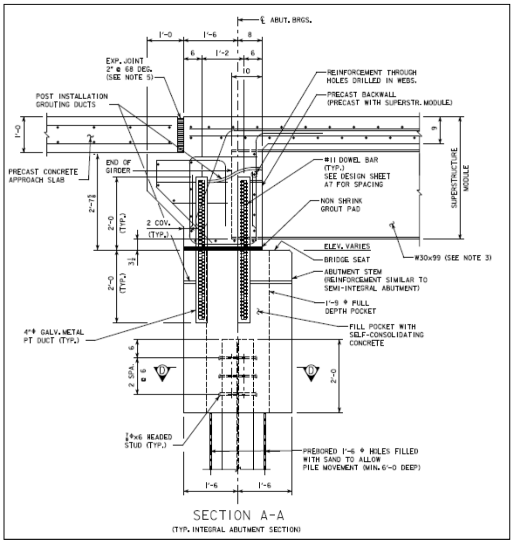
- They allow the joints to be moved beyond the bridge.
- Well suited for ABC.
- Close tolerances required when using expansion bearings, and joints are eliminated.
- The backwall is precast with the deck.
- Fast erection in 1 to 2 days.
- Economical.

Example: Iowa – Semi-Integral Abutment Suspended Backwall



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

Integral Abutment



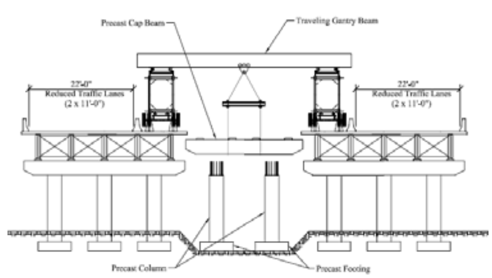
- Only one row of vertical piles
- Precast backwall - dowelled
- Fast construction

Example: Florida – Barge-Mounted Crane

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, new bridge (check capacity to support)
- Ideal for bridges with many spans, long viaducts

Launched Temporary Bridge

- Sites with limited ground access or long spans.
- Launched across or lifted over a span to act as a "temporary bridge."
- Used to deliver the heavier modules without inducing large erection stresses.
- Temporary bridge can also support transverse gantry. frames.

Longitudinal Gantry Frame Delivering Steel Modules

Erection Using Transverse Gantry Cranes

Questions

Lesson Five

ABC Construction Specifications

- The specification identifies responsibilities for design, construction, and inspection during an ABC project.
- Fabricator qualifications, and requirements for plant casting and site casting are defined.
- It identifies two phases of inspection: fabrication inspection and field inspection are the responsibility of the owner.
- Requirements for various connection types commonly used in ABC, including UHPC joints, are defined.

Erection Stresses

- The Engineer of Record is responsible for checking the handling stresses in the element for the lifting locations shown on the plans.
- The contractor may choose alternate lifting locations with approval from the Engineer of Record.

Loads for ABC Design

- **Construction Loads**
  - Loads associated with support conditions during fabrication - may be different than the permanent supports.
  - Loads associated with member orientation during prefabrication.
  - Loads associated with suggested lift point.
  - Loads associated with impact considerations for shipping and handling of components
  - Loads associated with camber leveling, etc.

Constructability Checks for ABC Design

- **Constructability Checks**
  - Evaluate lifting and erection stresses in components.
  - To what extent is cracking allowed during transportation and erection?
  - What are the limiting stresses /deflections/ distortion during transportation and erection?
  - Check requirements for SERVICE III in prestressed members.
  - Address bracing requirements during transportation and erection.

ABC Specific Construction Loads

- **Dynamic Dead Load Allowance**
  - An increase in the self-weight of components to account for inertial effects during handling and transportation.
- **Camber Leveling Force**
  - A vertically applied force used to equalize differential camber prior to establishing connectivity between the elements.

Analysis Requirements for ABC Design

- **Analysis Requirements**
  - What are the minimum recommended levels of analysis or stages of analysis required for bridges erected by various unique methods?
  - Consider sequence of loading during construction.
  - Are there any unique changes to structural load distribution that must be addressed for certain prefabricated bridge types and connection configurations?

Connections Design for ABC

- **Connections**
  - Requirements for closure pour design for strength and durability
  - Development of reinforcing steel and lapped splices in closure pours
  - Requirements for grouted splice couplers
  - Provisions for UHPC joints
  - Provisions for SCC connections

5.14.6 Provisions for Design of Prefabricated Systems for Accelerated Bridge Construction

- Loads and load factors discussed
- Load combinations
- Constructions loads
- Control of cracking (Non-Prestressed)

5.14.6 Provisions for Design of Prefabricated Systems for Accelerated Bridge Construction

- Lifting and handling stresses
- Prestressed component stresses
  - Before losses
  - Service stress limits
- Design of grouted splice couplers
- Closure joints

ABC Design Examples

- Three ABC design examples for prefabricated systems are included in the toolkit:
  - Decked Steel Girder
  - Decked Precast Prestressed Girder
  - Precast Pier
- Design Criteria:
  - AASHTO LRFD (5th Edition)
  - Supplemental ABC criteria

The design examples provide step-by-step guidance on the overall structural design of bridge components for ABC

Decked Steel Girder Example

Decked Steel Girder Design For ABC

Organization of Design Example	
I. General: Design Philosophy Design Criteria Material Properties Load Combinations **II. Girder Design:** Flexural Strength Checks Flexural Service Checks Shear Strength Fatigue Limit States	**III. Deck Design:** Flexural Strength Check Deck Reinforcing Design Deck Overhang Design **IV. Continuity Design:** Compression Splice Closure Pour Design

Decked Steel Girder Erection Stresses

- **Erection Stresses**
  - Ensure that the anticipated flexural tensile stress induced in the top of the structural concrete slab for the assumed support locations is no greater than allowable.
  - Enforce deck crack control under negative bending for pick points shown.
  - Check interior module and exterior modules with:
    - Precast barrier
    - Precast backwall
  - Specify minimum concrete strength during erection.

Decked Steel Girder Design Approach

- **Design Approach (Transverse Joint @ Pier)**
  - Simple span for DL, continuous for LL
  - Two bearings per pier on either side of the UHPC joint
  - The negative bending moment at the pier is used to find the force couple for continuity design (strength) – between compression plates at the bottom and the UHPC closure joint (tension) at the top.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | **Lesson 5** | Lesson 6

Decked Steel Girder Deck Design

- **Deck design**
  - 9” total deck thickness. Design thickness = 8”
  - ½” allowance for wear and ½” **allowance for grinding and profile adjustment**
  - Deck design essentially same as CIP construction
  - Constant deck thickness. Slope of the bridge seat conforms to cross-slope.
  - Cross slope break usually at longitudinal joint in deck
  - Allows faster on-site construction

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | **Lesson 5** | Lesson 6

Decked Steel Girder Deck Overlay

- **Deck Overlay**
  - Use of overlay is optional for ABC standard designs.
  - Owners could use an overlay as part of a long-term maintenance strategy for decks.
  - Overlay eliminates need for diamond grinding.
  - If a deck overlay is used, cross-slope adjustments can be accommodated in overlay.
  - Asphalt with membrane and rapid set thin concrete overlays allow quick installation.
  - Can also be done after bridge is re-opened to traffic.

Deck Prestressed Girder Example

Decked Prestressed Concrete Girder Design for ABC

- A "decked" concrete girder is a precast, prestressed concrete bulb-tee, or multi-stemmed girder with an integral deck manufactured in precast concrete plants.
- Most bridge engineers are familiar with precast prestressed girder design for conventional construction.
- Flange connections are designed to transmit moment and shear via a UHPC closure pour. Other rapid set concrete mixes can also be used.
- Limit shipping weights to 200 Kips.

ABC Design Example – Deck Bulb Tee

Organization of Deck Bulb Tee Design Example	
General: Design Philosophy Design Criteria	Concrete Stresses at Release Concrete Stresses at Erection Concrete Stresses at Final
Girder Design: Permanent Loads Precast Lifting Weight Live Loads	Flexural Strength Shear Strength Negative Moment Design
Prestress Losses—Erection Prestress Losses—Final	Camber and Deflections at Release /Erection/Final

*** Engineer of Record should perform own ABC design

Decked Prestressed Concrete Girder Limits on Concrete Stresses

- Limits on concrete stresses at three stages:
  - At transfer
  - At erection
  - At final
- Compute prestress losses at all three stages.
- The cross-section of the girder remains unchanged through the various stages of ABC construction.
- Use appropriate concrete strengths.

Concrete Tensile Stresses

Service Limit State after Losses

- LRFD Section 5.9.4.2.2 allows 0.19 f c' (ksi) tensile stress in the precompressed tensile.
- **However, due to high calculated flexural tensile stresses from camber leveling forces in DBT girders, an allowable of 0 tensile stress is included in the design guidelines.**
- This criterion provides a margin of tensile capacity to help compensate for camber leveling tensile stresses.

Concrete Tensile Stresses at Erection

- No cracking during transportation and erection for the lift points selected
- Allowable tension = 0.24 $\sqrt{f'_{cm}}$ (ksi)
- Limited tension to modulus of rupture with a F.S = 1.5
- 30% Impact
- Concrete stresses calculated for the effective prestress force using only the losses between transfer and erection

Prestress Losses at Erection

- Time to erection assumed (say 30 days)
- Time-dependent losses from transfer to erection
  - Relaxation of prestressing steel
  - Shrinkage of concrete
  - Creep of concrete
- Separate calculations for each time-dependent component
- Concrete stresses and camber calculated using effective prestress at erection

Decked Prestressed Concrete Girder Camber Control for ABC

- Camber-leveling methods include:
  - Jacking: A cross beam and hydraulic jacks are used to adjust the elevations of the girder surfaces to a level condition.
  - Surcharging: Heavy weights are loaded onto the tops of girders to reduce differential camber.
- Camber leveling force used to equalize differential camber needs to be factored into the design of the girder.

Toolkit Tour

- Let's take a look in the Toolkit
  - Sample Calculations/Specifications (Page 31)
  - General Information Sheets (Page 44)
  - Sample Designs, Steel (Page 120)
  - Sample Designs, Prestressed (168)
  - Design Specifications (277)
  - Construction Specifications (Page 285)

Questions

171

Lesson Six

1. Introduction to Accelerated Bridge Construction (ABC)
2. Prefabricated Elements and Systems
3. Bridge Movement Technologies
4. ABC for Designers – Part 1
5. ABC for Designers – Part 2
6. **ABC Examples: Keg Creek Project (Iowa) and I-84 (New York State DOT)**

ABC Demonstration Pilot Projects

- US 6 Bridge over Keg Creek, Council Bluffs, Iowa

Iowa Department of Transportation

- I-84 Bridges over Dingle Ridge Road, New York

Modular Construction (IADOT)

14-day ABC period: October 17 to November 1, 2011

Old Keg Creek Bridge

New Bridge Following Construction

US 6 Bridge over Keg Creek -- Bids

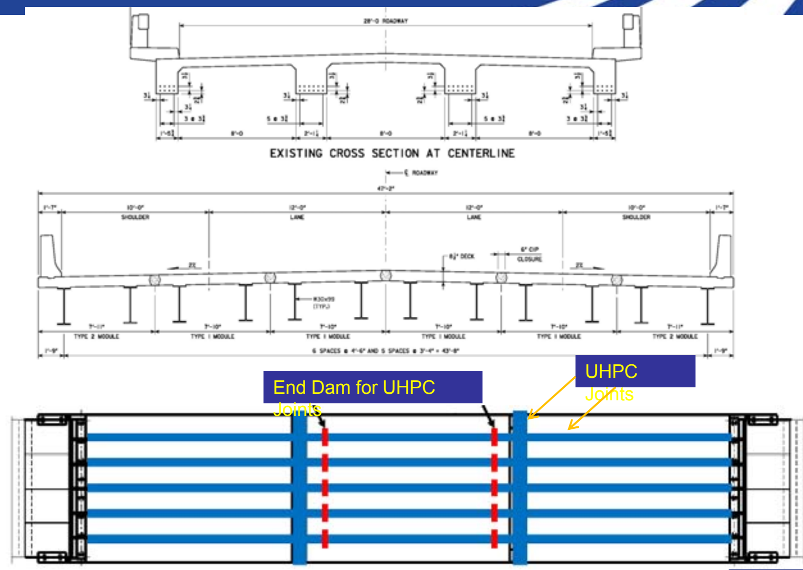
- Seven local bidders
- Contract letting: Feb 2011
- Contractor: Godbersen-Smith
- Construction, Ida Grove, IA
- Low Bid: $2.67 million
- Bridge cost = $231/SF
- Incentive/Disincentive = $22,000/day during 14-day ABC period
- HFL funds $600,000; SHRP 2 funds $250,000

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

US 6 Keg Creek Bridge Site Layout

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Cross-Sections/Plan



Keg Creek ABC Design Highlights

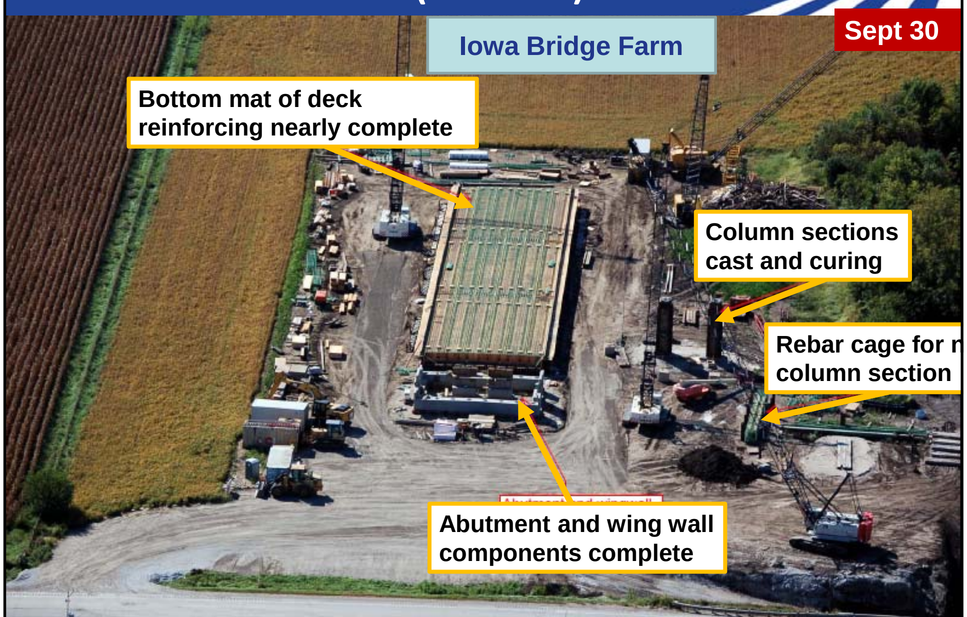
- Complete prefabricated bridge, including approach slabs
- UHPC, SCC, grouted splice coupler connections for rapid field assembly
- HPC concrete. No open joints.
- First bridge in U.S. with full, moment-resisting UHPC transverse joints at the piers
- Semi-integral abutment for rapid superstructure construction
- Flooded backfill for rapid substructure construction

Stage 1 (Pre-ABC) Drilled Shafts Foundations

- Pier foundations were completed pre-ABC period:
  - Foundations built outside the existing bridge footprint as new bridge was wider (6 ft. dia. 75 ft. long)

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Prefabrication Yard (Pre-ABC)

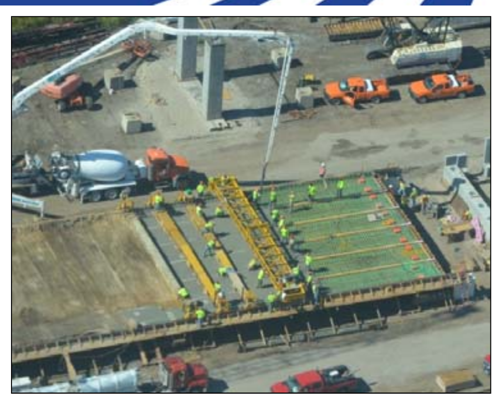


Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Lesson 6

Prefabrication of Abutments and Piers

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Prefabrication of Steel Modules



- Steel was fabricated in the shop.
- The deck concrete was cast on-site.
- Contractor chose to prefabricate modules in their exact relative location.

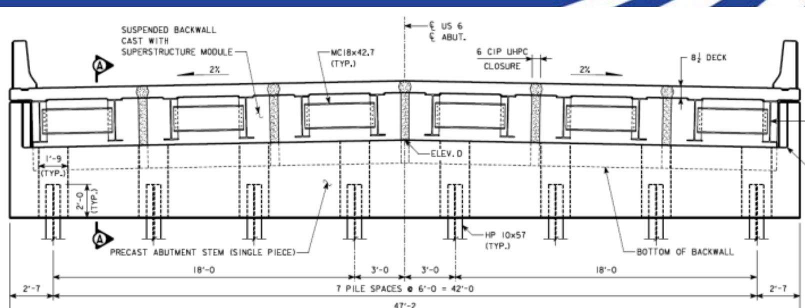
Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Stage 2 (ABC Period) Rapid Demolition

Day 1
Oct 17

- Completed within a single day
- Two hydraulic breakers mounted on excavators
- Crane with wrecking ball

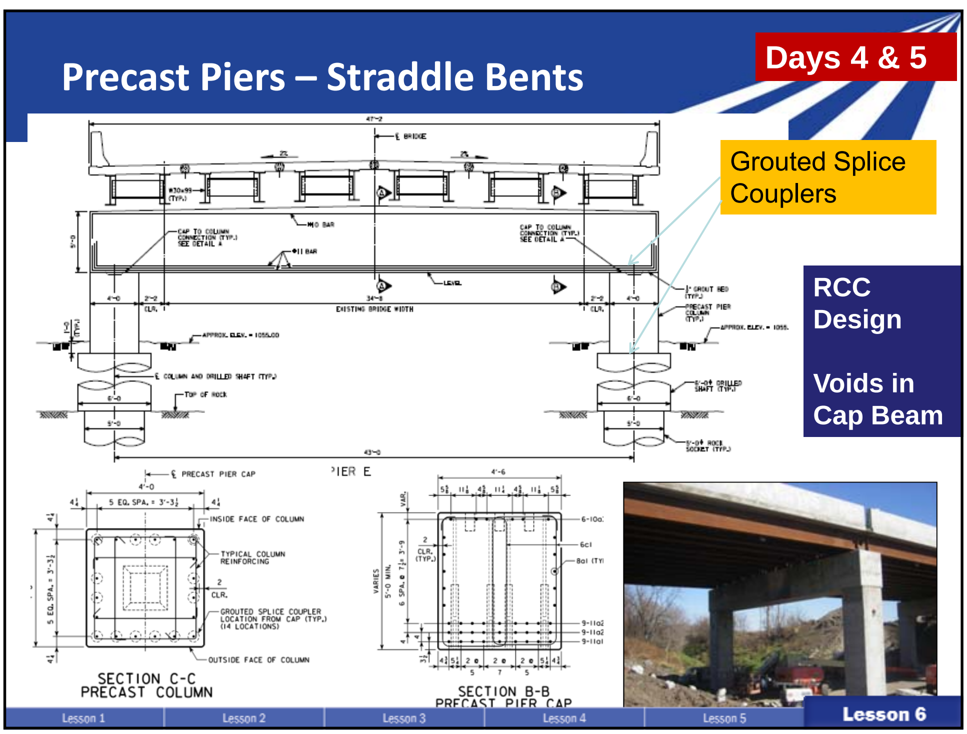
Precast Abutment Details



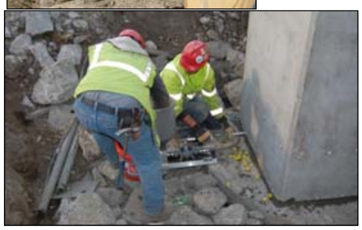
Precast Abutment Construction

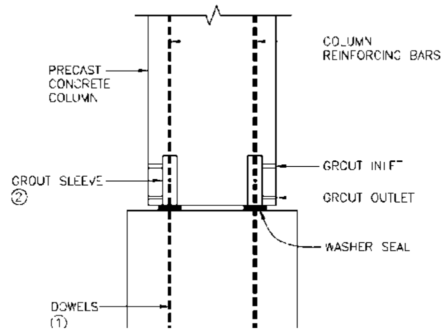
- Single row of H-piles were driven
- SCC to fill pile pockets
- U-shaped wingwalls


Precast Abutment Assembly
Days 3 & 4
Lesson 1
Lesson 2
Lesson 3
Lesson 4
Lesson 5
Lesson 6


Precast Piers – Straddle Bents
Days 4 & 5
Grouted Splice Couplers
RCC Design
Voids in Cap Beam
SECTION C-C
PRECAST COLUMN
SECTION B-B
PRECAST PIER CAP
Lesson 1
Lesson 2
Lesson 3
Lesson 4
Lesson 5
Lesson 6

Grouted Splice Coupler



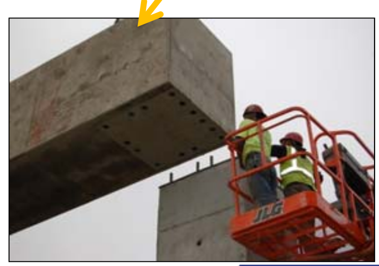


Precast Pier Assembly

Day 5

- Pier caps–168 kips.
- Required two 110-ton cranes to lift into position.

168 K



Erection of Superstructure Modules

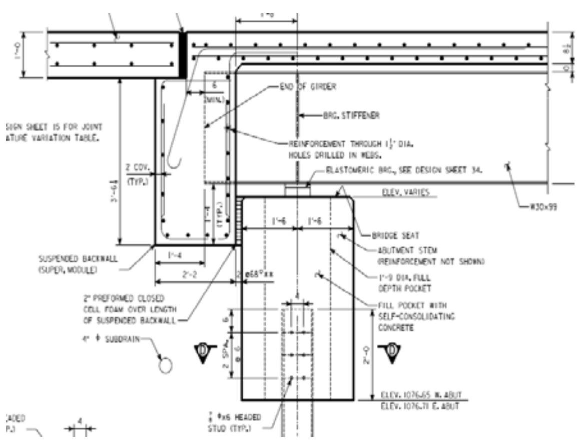
Days 7 & 8

112 K

Span = 70 ft

Semi-Integral Abutment Suspended Backwall

Days 7 & 8

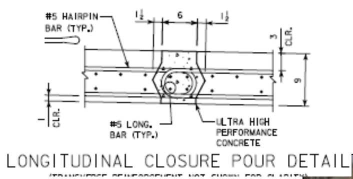


- Allows superstructure expansion/contraction
- Easy fit up
- Well suited for rapid construction

UHPC Joints in Bridge Deck

Day 10

- Full moment transfer. No post tensioning required.
- Only 6 in. wide. High strength; low permeability.
- Can be reinforced with hairpin bars or straight bars.

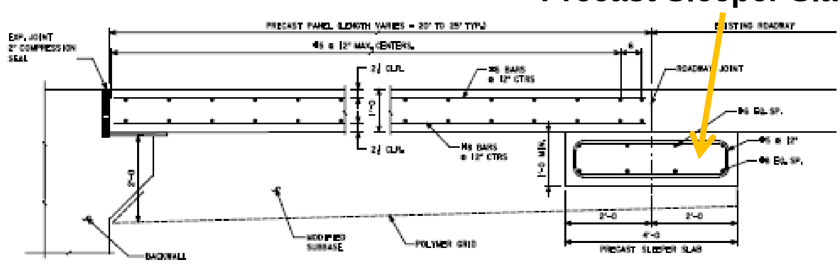


Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Precast Approach Slab

Day 10

Precast Sleeper Slab



Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

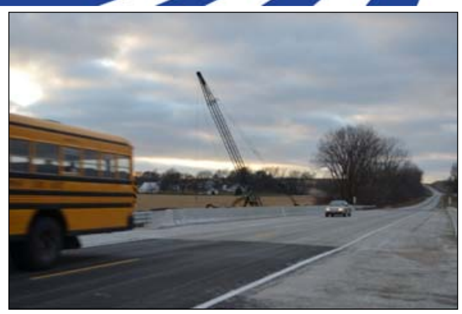
Deck Riding Surface

Day 13

- No open deck joints
- Integral wearing surface—overlay not required
- Extra ½ in. for grinding for smooth riding surface
- Longitudinal grooving for skid resistance

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Nov 1, 2011 – Ready for Traffic



Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Post-Construction Review
Lessons Learned

- Best to have two independent surveys as survey errors can lead to major delays during ABC period.
- Could specify longer pile lengths by contract to minimize schedule disruptions.
- Designer should be present on-site during the ABC period for quick decision making.
- Pre-pour meeting with UHPC supplier and follow procedures. Bond between UHPC and deck is critical.
- UHPC reinforcement should allow joints to be more easily and quickly constructed. Straight bars preferred.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

I-84 Over Dingle Ridge Road, NY

- 50 miles north of New York City
- NYC watershed area
- Over 75,000 to 100,000 ADT
- Major truck route
- Existing bridges are too narrow for two-way traffic with cross-overs (28 ft. wide roadway)
- NYSDOT was planning to use a temporary bridge in the median at a cost of $2.0 M to maintain traffic.
- Each bridge would take one construction season.

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

I-84 Over Dingle Ridge Road, NY
Lateral Slide

- Nov 2012 letting
- 2012–13 construction
- Overnight replacement

I-84 EB & WB Bridges over Dingle Ridge Road

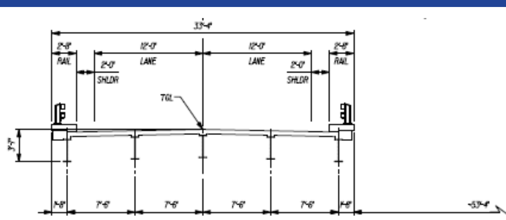
Overnight Lateral Slide

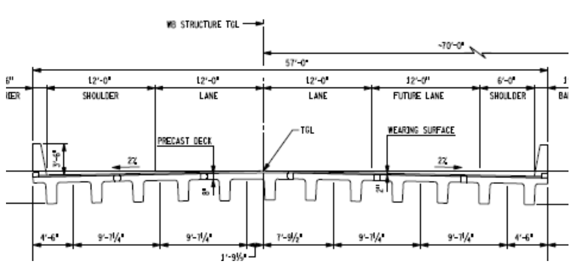
- Eliminates need for a temporary bridge & cross-overs.
- Traffic disruption on I-84 reduced from two years to two weekend nights (16–18 hr closures).
- Dingle Ridge Road (low volume) will be closed longer to complete the demolition.
- Slide-in new single span concrete superstructure and approach slabs at the same time for faster construction.
- Bid opening November 2012
- HFL funds: $2.0 M
- SHRP2 funds: $300,000

I-84 Dingle Road Bridge Design Considerations

- Single span 80'; three lanes at 12'
- Left shoulder 6', right shoulder 12'
- Bridge width 33'-4" → 57'-0"
- Provided room for future traffic control
- Used 2" asphalt wearing surface to eliminate grinding
- Under-passing Dingle Ridge Road on 15.7% grade
- New bridges would be about two feet higher than the existing to provide under-clearance

Typical Sections





New bridge is wider

Construct abutment drilled shafts outside footprint

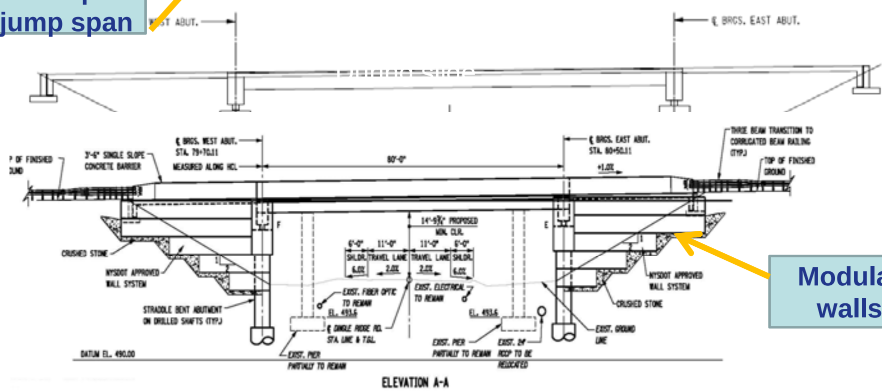
NEXT beam (double T beam) superstructure

Precast approach slabs

Longitudinal Elevation

Temp. jump span

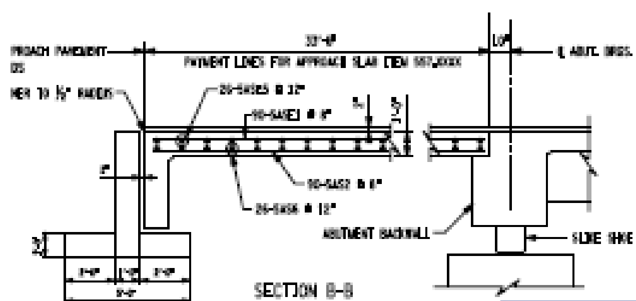
Slide Surface



Modular walls

Sleeper Slab/End Dam

End dam retained the approach pavement that was raised by 2 ft. during ABC period.



New Abutment Construction

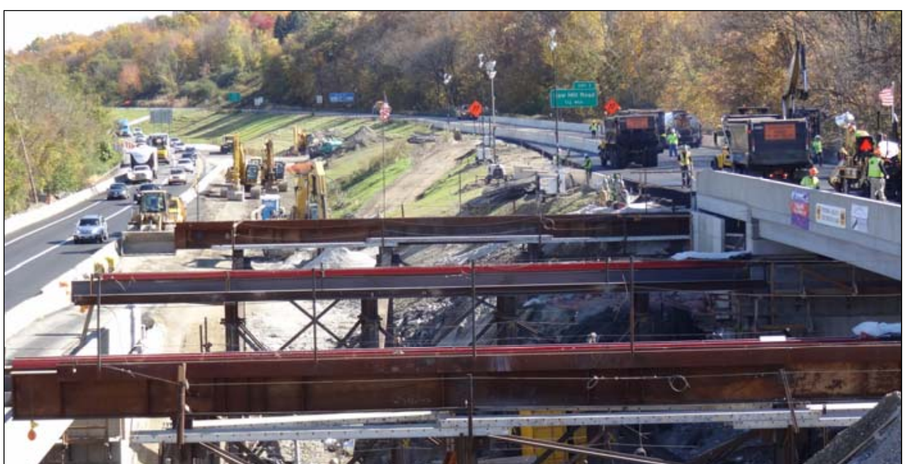
Abutment Slide Surface

16 Gauge PTFE Bonded to Elastomeric Bearing Pad

New Bridges Build Alongside Existing Bridges

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Lateral Slide -- October 21, 2013



7 hours to demolish exist bridge and slide-in new bridge

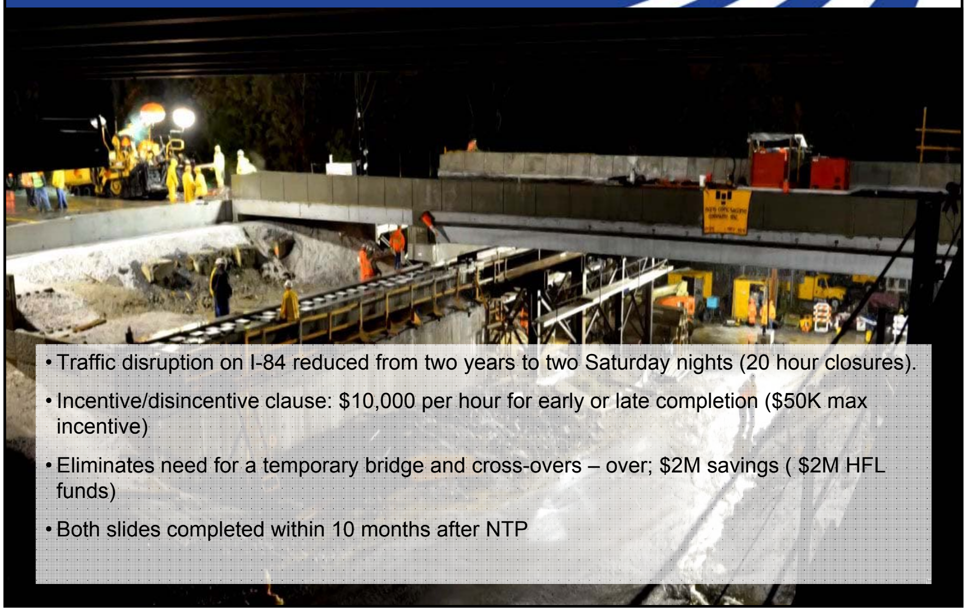
Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

Both Bridge Slides Completed 10 Months After NTP

Both Bridges Completed in Two Weekends

Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | **Lesson 6**

ABC Design – Slide-In Replacement



- Traffic disruption on I-84 reduced from two years to two Saturday nights (20 hour closures).
- Incentive/disincentive clause: $10,000 per hour for early or late completion ($50K max incentive)
- Eliminates need for a temporary bridge and cross-overs – over; $2M savings ($2M HFL funds)
- Both slides completed within 10 months after NTP

Post-Construction Review Lessons Learned

- **Construction** duration significantly reduced from two construction seasons to two weekends.
- **Safety** within the work zone improved.
- **Reduced Costs:** $2.0 M saved, primarily by not building the crossovers and temporary bridge in the median.
- **Impacts** to the New York City watershed substantially reduced; at least 5 acres of land did not have to be disturbed with the ABC.

Questions

H-Pile Supported Abutment and Walls for ABC

Resources

- Jamal Elkaissi at FHWA, jamal.elkaissi@dot.gov
- Patricia Bush at AASHTO, pbush@aashto.org
- Finn Hubbard, R04 Subject Matter Expert, FHubbard@fishassoc.com

- Toolkit, guides, case studies, presentations, and video available at: http://shrp2.transportation.org/Pages/Bridge-Designs-for-Rapid-Renewal.aspx

  and
- https://www.fhwa.dot.gov/goshrp2/Solutions/Renewal/R04/Innovative_Bridge_Designs_for_Rapid_Renewal

Questions

214




SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Innovative Bridge Designs for Rapid Renewal
SHRP2, R04
Case Studies and Lessons Learned

Finn Hubbard, Fish & Associates Inc.
SHRP2 ABC/PBES Implementation
Technical Lead

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

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

1

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

2

Gila River - Arizona

Gila River - Arizona

Gila River - Arizona

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

6

Fort Goff Creek, California

Stewarts Creek, Kentucky

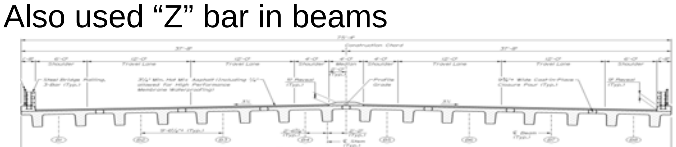
- Replaced 2 bridges using R04 ABC techniques.
- A + B bidding, (Cost plus time)
  - Shorten closure time
  - Total project only 38 days
- Galvanized and painted steel superstructure
- Galvanized deck rebar
- Super in 2 longitudinal pieces
- Preassembly worked great

8

Stewarts Creek, Kentucky

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



10

Kittery Overpass, Maine

11

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

13

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

14

Route B Bridge, Boone County, Missouri

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

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

19

I-39/90, Wisconsin

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

22

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

23

Seney National Wildlife Refuge, Michigan

Michigan

Seney National Wildlife Refuge, Michigan

Three R04 Showcases
Three Peer to Peer Exchanges

- Implementation projects, Showcases and Peer to Peer exchanges provided various lessons learned

27

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

28

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

29

Identify Goals at the Onset

- Identify the main goal of the project
    - Least disruption of traffic?
    - Least cost?
    - Environmental protection?
    - Length of construction season?
    - Length and ability of detour?

30

R04 Toolkit Aids Policy Decisions

- The SHRP2 Toolkit can help when considering ABC alternatives.
  - Precast construction
  - SIBC

31

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!

32

Technical Lessons Learned

- Foundations selection can be a significant issue. Spread footing are fast.
- Post tensioning works, but takes time.
- UHPC is a good tool, but expensive. Make sure forms are watertight
- Weight of precast elements can pose issues.
- Shop reviews require detailed attention. Best to have issues on paper

33

Technical Lessons Learned

- Geosynthetic Reinforced Soil (GRS) abutments are fast and inexpensive
  - Scour needs to be considered in their use
- ABC can help with some weather issues
- Grouted bar splice couplers work well for ABC
- Deck overlays solve deck alignment issues

34

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!

35

Owner Lessons Learned

- DOTs need to be innovative to stay relevant.
- Durable joints must 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.
- **DOTs can gain real political capital from ABC.**

36

Contractor Lessons Learned

- Contractors like to retain as much work as possible.
- Contractors bid labor, material, and risk.
- Contractors like CM/GC contracts.
  - Geared to their means and methods
- Contractors have good suggestions; work with them.

37

General Consensus

- Important to assemble an “A” team
  - Owner
  - Designer
  - Contractor
- Not every project requires an ABC solution, but those that do realize significant benefits.

38

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?

40

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

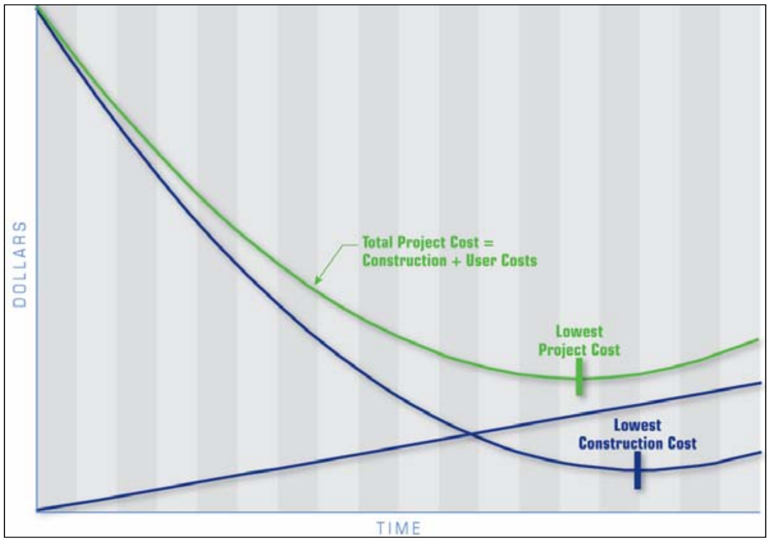
Cost Implications of Rapid Renewal Projects

"Total" Project Costs
Contractors and ABC

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Total Project Cost = Construction Cost + User Cost



1

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

2

Evaluating ABC Costs

Σ(Project Cost) =

$$\sum_{t=0}^{Serive\ Life}(planning, design, procurement, construction, maintenance)_{cost}$$

ABC Cost Impact?

3

How Much Does ABC Cost?

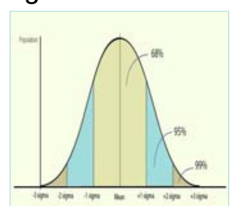
It depends…..

- *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

4

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



5

How Do Contractors Bid Risk?

- *Perform a risk analysis for critical features of the construction*
  - Determine the probability of failure for various functions
  - Apply it to the disincentives
- *Option 1: Investigate ways to minimize risk*
  - Add labor
  - Add equipment
  - Add specialty sub-contractors
    - More experience to the team
    - Spread the risk out to more than one entity
  - This all adds cost
- *Option 2: Bid the risk*
  - Increase the bid to account for risk factors

6

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

7

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
- CMGC
  - Risk management is a big part of this procurement process

8

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

9

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

10

Contractors and ABC

- **Making the Case for ABC with Contractors**
  - Contractual incentives/penalties
  - Market edges
- **Procurement**
  - Schedule
  - Constructability
  - Risks
  - Benefits
- **Success Story (Arizona) with Contractors**

11

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

12

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

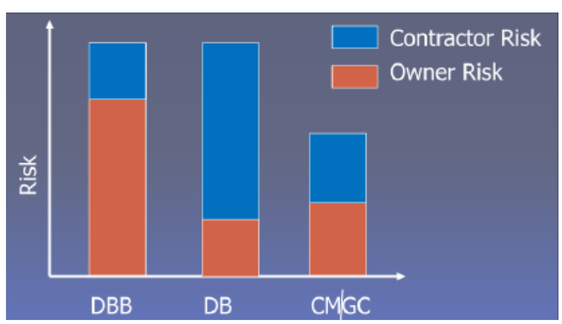
Risks

- Liquidated damages
- Tight schedule
- Weather
- Subcontractors
- Worker fatigue
- Equipment breakdown
- Unknown territory

13

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



14

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
- What about Design/Build?

15

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 details, flaggers, etc.

16

Iowa Example: Keg Creek Cost Savings

- From a construction cost standpoint, the ABC delivery **approach** cost the Iowa DOT $1,169,293 more than traditional construction ***but*** **saved** ***time users would have otherwise been detoured.***
- Considering the savings in user costs of $1,609,785 from combined VOC and delay costs ($994,519 + $615,267) the cost differential is **$440,492** or ***29 percent less than traditional construction for a project of the same size and scope.***

17

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

18

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!**

19

Conclusion

- 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

20

Questions

21

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Status of State Accelerated Bridge Construction (ABC) Implementation

Overview of Projects Presented at Three R04 Peer-to-Peer Exchanges

Finn Hubbard, Fish & Associates Inc.
SHRP2 ABC/PBES
Subject Matter Expert

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Lessons Learned from R04 Peer Exchanges

- States have embraced ABC methods.
- Many questions were raised:
  - -How do you set up ABC on a statewide basis?
  - -How do you decide if an ABC approach is correct or warranted?
  - -What are reasonable cost expectations for ABC projects?

California R04 Project




Fort Goff Creek Bridge

ABC Samples in Colorado

I-70 Glenwood Canyon Precast Segmental Bridges built by Span-by-Span Launching

Montana ABC Project

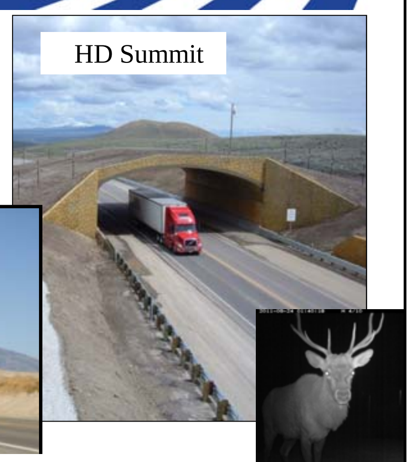
Modular Steel I-Girders with Integral Concrete Deck and CIP End Walls

Nevada PBES/ABC Projects

B-1942 Tuscarora

Bridge Replacements
- Performance Specs
- Prefabricated Bridge Rail/Headwalls/Wingwalls
- Structure Placed in 1 Day

Nevada PBES/ABC Projects



Safety Crossings
- Performance Specs
- Temporary Road Closures

New Mexico ABC Application

I-10/Avenida de Mesilla Interchange – Full-Depth Full-Width Precast Deck Panels

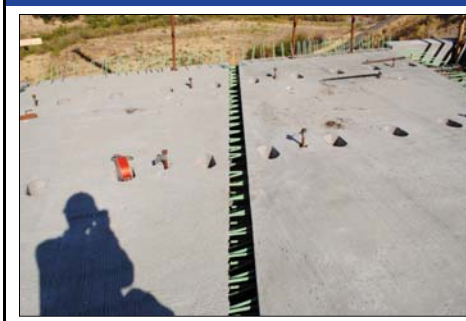
New Mexico ABC Application

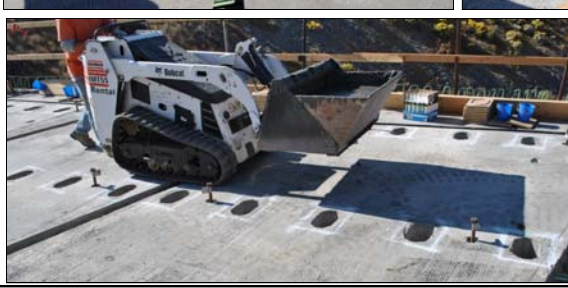
Panels after Placement

Oregon DOT ABC Project

- Applying precast prestressed deck panels with UHPC joints
- US 30 Burnt River (UPRR) 2012

Oregon DOT ABC Project





US 30 Burnt River (UPRR)

Washington State ABC Project

I-5 Skagit Bridge Collapse & Replacement

- Truss Collapse, I-5 near Mount Vernon on May 23
- Over height load struck critical steel supports.
- I-5 carries ADT = 71,000

Bridge Move Summary:

- Temporary Span out (25 min.)
- Permanent Span in (45 min.)
- Deck Lowering (30 min.)
- Traffic was the driver here

Wisconsin ABC Project

Completed - Superstructure lateral slide in 2011

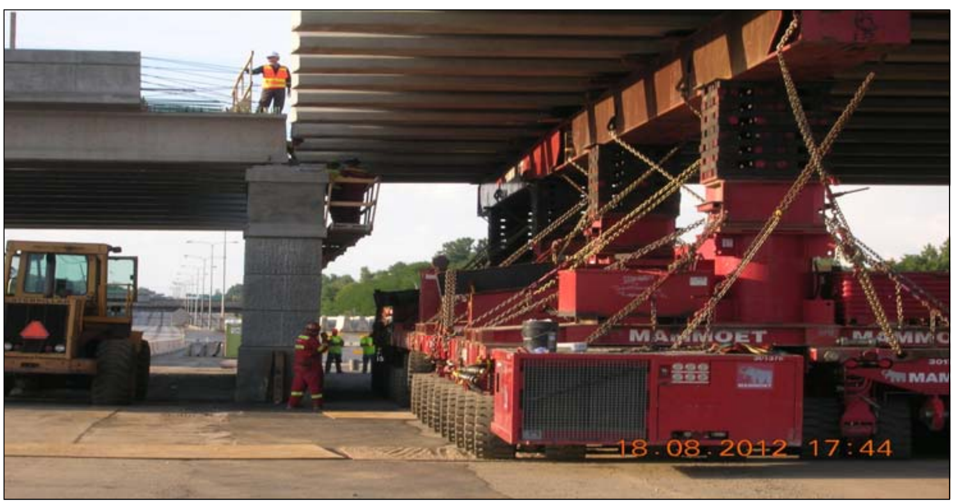
STH 29 (B-5-648/649)

12

Minnesota ABC Project

Maryland Avenue

Minnesota ABC Project



Traffic congestion. Get in, get out!

Michigan ABC Project

Geosynthetic Reinforced Soil (GRS)

15

Iowa ABC Project

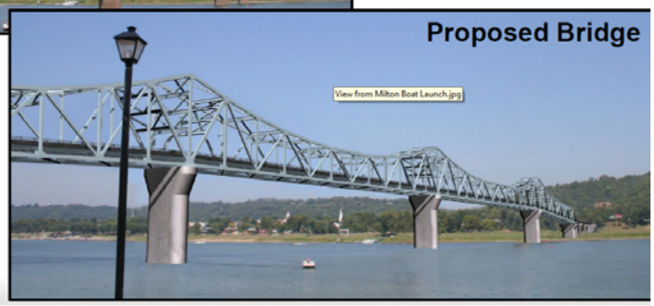
Massena Bridge – Lateral Slide

Iowa ABC Project

Vermont ABC Project

Indiana ABC Project

Milton Madison
Bridge Slide



Alaska ABC Project

Precast Decked Bulb-Tee Girders

- Still require 7 days for rail curb pour/cure
- Require crane(s), heavy to transport

Massachusetts ABC Project

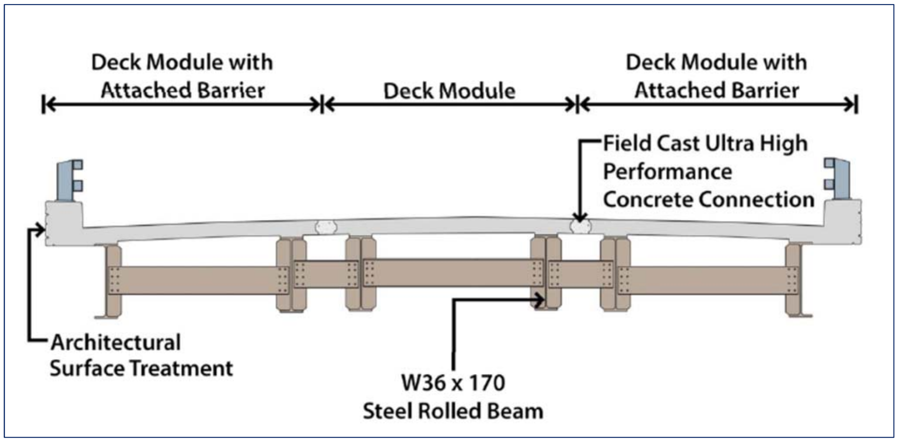
Medford – I-93 Fast 14 Project

- 14 structures carrying I-93 over various roads and the Mystic River
- ADT: 200,000 in each direction
- Urgent need for emergency repairs and superstructure replacements
- Substructure repairs performed in spring
- All 14 superstructures replaced in a series of 10 consecutive 55-hour work weekends in a single summer.
- No impact to weekday rush hour traffic

Massachusetts ABC Project

Fast 14 Project – Friday night, 10 PM, Demolition Starts

Pennsylvania ABC Project



Integral Abutment ABC Bridge

23

Pennsylvania ABC Project

Beam-Deck Modules
Were Set in 3 Hours

24

Kentucky ABC Project

Riley Bridge

Nebraska ABC Project

Girders were blocked to match final

26

Nebraska ABC Project

Nebraska Department of Roads place girder/deck units

27

Connecticut ABC Project

Rehabilitation project o
I-84 over Marion
Avenue in Southington

Connecticut ABC Project

Completed Bridge in Southington

Rhode Island ABC Project

- The I-95 southbound structure was the second to be moved
- Took place on August 27, 2014.
- Route 2 shutdown at 12:00 PM and opened at 3:50 PM
- Less than 4 hours of closure

Delaware ABC Project

Delaware DOT Replacing Bridges 1-676 and 1-677

Louisiana ABC Project

- Louisiana Prefabricated Systems
- New Construction – Large Projects, 28 miles

New Jersey ABC Project

NJDOT Superstructure Replacement Project

Georgia ABC Project

Georgia DOT Precast Substructure

Puerto Rico ABC Project

AUTORIDAD DE CARRETERAS Y TRANSPORTACION

Kentucky ABC Project

Replacing Kentucky Eggners Ferry Bridge after Accident

Not a good day at the office

Kentucky ABC Project

Great Recovery in 4 Months

Texas ABC Project

- Eliminates many tasks associated w/ CIP construction
- TxDOT Research
  - Project 1748
  - Project 4176
- Grouted vertical duct connections

Thank You for Participating!

- Please remember to fill out your PDH form and keep it for your records.
- We encourage you to take a moment and fill out our evaluation form so we will know how to improve on our training.
- All of this information and more can be found:
  - SHRP2 AASHTO web site http://shrp2.transportation.org/Pages/Bridge-Designs-for-Rapid-Renewal.aspx
  - FHWA's SHRP2 site: https://www.fhwa.dot.gov/goshrp2

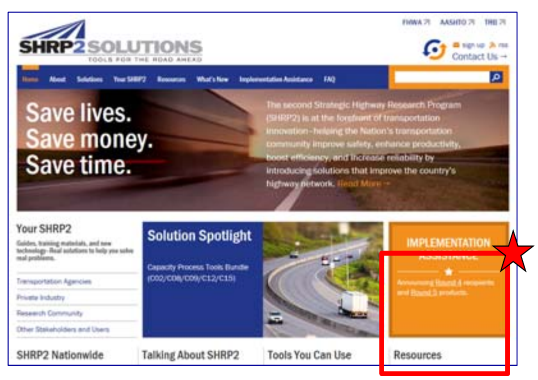
39

For More SHRP2 Information

Jamal Elkaissi
FHWA SHRP2 Engineer
(720) 963-3520
Jamal.Elkaissi@dot.gov

Patricia Bush
AASHTO Structures Lead
(202) 624-8181
PBush@AASHTO.org

Finn Hubbard
Sr. VP, Fickett Structural Solutions
608-215-7862
fhubbard@fickettinc.com



Simply Google "SHRP2"

Questions