ABC Training Outline
2:30 hrs

1. Introduction to ABC (30 min)

2. SHRP2 Project R04 -- ABC Toolkit (70 min)

3. ABC Pilot Projects (50 min)
   - Prefabricated bridge system (Iowa)
   - Lateral slide (NY)
Session 1

Introduction to ABC
What is Accelerated Bridge Construction (ABC)?

ABC is bridge construction that uses design and construction methods to reduce the onsite construction time and mobility impacts that occur when building new bridges or replacing and rehabilitating existing bridges.
ABC for Emergency Replacement

I-10 spans on Lake Pontchartrain after katrina

ABC for Planned Replacement
Conventional Bridge Construction

- Cast-in-place construction is field labor intensive
- Sequential construction
- Time consuming on-site activities
- Needs to allow time for concrete curing
- Weather dependent
Why Faster?

• For most of the past century, construction has involved building roadways and bridges with new alignments.

• Today, very little new roadway systems are being constructed.

• Today’s projects impact the traveling public tremendously.

• ABC methods provide the ability lessen the duration of bridge construction from the critical path.
Time Metrics for ABC

**Onsite construction time**: The period of time for completing all construction-related activity.

**Mobility impact time**: Any period of time the traffic flow is reduced due to onsite construction activities.

- Tier 1: Traffic Impacts within 1 to 24 hours
- Tier 2: Traffic Impacts within 3 days
- Tier 3: Traffic Impacts within 2 weeks
- Tier 4: Traffic Impacts within 3 months
- Tier 5: Overall project schedule is significantly reduced by months to years
ABC Advantages

• Reduces disruption to traffic / avoids congestion
• Safer; Reduces exposure of workers and public to construction activities
• Better quality control of precast elements
• Reduced Environmental impacts
To develop standardized approaches to designing, constructing, and reusing complete bridge systems that address rapid renewal needs.
SHRP2 Vision/Goal for ABC

Standardize Prefabricated Bridge Elements and Systems

Make Accelerated Bridge Construction Standard Practice
INNOVATIVE BRIDGE DESIGNS FOR RAPID RENEWAL

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

Dr Monica Starnes, Senior Program Officer SHRP2
SHRP2 Project R04

Phase I – Define ABC Challenges
  • Owner & Contractor surveys / focus groups

Phase II – Identify & Refine the Best ABC Technologies

Phases III & IV – Standardize & Deploy ABC
  • ABC Toolkit
  • ABC Pilot Projects

Phase V – Beta testing of ABC Toolkit by VAOT
ABC ELEMENTS & METHODS

Accelerated Bridge Construction (ABC)

- Prefabricated Elements
- Prefabricated Modular Systems
- Structure Placement Methods
- Accelerated Geo-tech Work

Phases IV (2011-2013)
Definition of PBES

PBES are structural components of a bridge that are built offsite, or adjacent to the alignment, and includes features that reduce the onsite construction time and mobility impact time that occurs from conventional construction methods.
What are Prefabricated Elements

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

*Goal is to move construction activities related to casting of concrete off-line to avoid traffic disruptions*
Prefabricated Elements
Full Depth Precast Deck Panels
Segmental Columns
Accelerated Construction of Bridges Using PBES

- MassDOT I-93 FAST 14 Project – interior module
What are Prefabricated Systems

- **System:**
  - Superstructure
  - Substructure
  - Total Bridge

Total bridge or superstructure system can be fabricated off-site and moved with SPMTs, or, fabricated adjacent to existing bridge and moved by skidding.
Elements vs Systems

- Elements
- Systems
The concept of building the entire bridge superstructures (where ROW is available) and then moving them into place in a few hours is a powerful ABC method to minimize traffic disruption.

Bridge movement technologies
- Self-propelled modular transporters (SPMT)
- Skidding / Lateral Sliding
- Longitudinal Launching
- Float in
Self Propelled Modular Transporter

• **What is an SPMT?**
  - large multi-axle platform
  - computer-operated
  - pivots 360 degrees
  - lifts, carries, sets large/heavy loads
  - moves at walking speed
Bridge Moves with SPMTs
SPMT Manuals

Utah Department of Transportation

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

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

Sponsored By:
Federal Highway Administration
American Association of State Highway and Transportation Officials
National Cooperative Highway Research Program
Florida Department of Transportation
New York City: *Lateral Slide*
Jamaica & Hillside Ave. over Van Wyck Expwy
New Bridge with Traffic
I-80 Bridge Move Using Jacks
Green Bay Wisconsin
Lateral Slide by Pulling with a Crane
• Lateral Slide
• Four strand jacks
Longitudinal Launching

Superstructure was delivered to the site on a SPMT and transferred onto a launching frame for longitudinal launching (Utah DOT)
Incremental Launching

The Incremental Launching Method (ILM) involves assembly of the bridge superstructure on one side of an obstacle to be crossed, and then launching of the superstructure longitudinally into its final position.

The ILM can be used to construct a bridge over:
- Deep valleys
- Deep water crossings
- Environmentally protected areas

Over 1000 bridges worldwide have been constructed by this method – mostly in Europe.
Launching of US 48/WV 55 bridge over Clifford Hollow, Moorefield, West Virginia
Incremental Launching of US 20 Bridge over the Iowa River, IA.
Incremental Launching of Segmental Slab System

- Incrementally launched concrete slab bridge
- Launched over electrified rail lines with 340 trains per DAY. No speed restrictions
- All work performed at ground with small crews / equipment
Accelerated Geotech Methods

Example: Geofoam Embankment
Rapid Demolition

• Because the demolition operations may require roadway closures, completing the demolition quickly is as critical as the replacement operations.

• Rapid demolition can be done using conventional equipment or specialized equipment
Rapid Demolition Using Conventional equipment
Rapid Demolition Using SPMTs

4500 South over I-215 (2007) Utah
Existing bridge spans removed using SPMT and demolished offsite
Early Example of ABC!
QUESTIONS ?
NY STATEWIDE CONFERENCE ON LOCAL BRIDGES 2012

Accelerated Bridge Construction
ABC

Bala Sivakumar
HNTB Corp.
New York
Session 2

ABC Toolkit for Designers from SHRP2

- Introduction to ABC Toolkit
- ABC Conceptual Plans
- ABC Conceptual Erection Concepts
- Using the ABC Toolkit
- ABC Design Sample calculations
- Recommended ABC Specifications
ABC Toolkit

- SHRP2 ABC Tool Kit was developed for prefabricated elements and systems
- Will bring about greater familiarity about ABC technologies and concepts and also foster more widespread use of prefabricated elements
- Make best use of program dollars by standardizing design through development of pre-engineered systems
Expected Outcome: The designer, guided by the sample drawings, details and the set of ABC design examples will be able to easily complete an ABC design for a routine bridge replacement project.
<table>
<thead>
<tr>
<th>ABC CONCEPTS (Design + Erection)</th>
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<tbody>
<tr>
<td>• Decked Steel Stringer</td>
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<tr>
<td>• Decked precast girder</td>
</tr>
<tr>
<td>• Complete precast pier</td>
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<tr>
<td>• Precast abutment and wingwalls</td>
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<tr>
<td>• Precast approach slabs</td>
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<td>• Erection Concepts</td>
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<th>ABC DESIGN EXAMPLES</th>
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<th>ABC DESIGN SPECIFICATIONS</th>
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<tr>
<td>• Recommended enhancements to LRFD to support ABC</td>
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</table>

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<tr>
<th>ABC CONSTR. SPECIFICATIONS</th>
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<tbody>
<tr>
<td>• Construction specs for ABC modular systems</td>
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</tbody>
</table>
ABC Design Concepts
ABC Design Concepts

GOALS:

• Focus on “workhorse’ bridges
• Complete bridges using prefabricated elements and modular systems
• Simple to fabricate onsite or in a plant and easy to erect using conventional equipment
• Fast assembly in the field in 1 to 2 weeks
• Durable connections
Standardizing ABC Concepts

• Standardized prefabricated elements increase their availability thereby reducing costs and lead times.
• Standardizing makes these ABC system more familiar to engineers and contractors, which will reduce complexity and the level of risk.
• By increased usage and repeatability, the economies of scale over time will result in reduced costs.
• Repeated use of a standardized ABC concept also allows continuous improvement.
Design Considerations for Prefabricated Elements

• Details to eliminate deck joints.
• Prefabricated Elements that do not require post-tensioning for assembly
• Prefabricated Elements with integral wearing surface so that an overlay is considered optional.
• Prefabricated Elements that can be used in simple spans and in continuous spans (simple for DL and continuous for LL).
Conceptual ABC Drawings

- **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
Conceptual ABC Drawings

ABUTMENTS & WINGWALS
- Semi Integral Abutments
- Integral Abutments
- Wingwalls
- Pile Foundations and Spread Footings

PIERS
- Precast Conventional Pier
- Precast Straddle Bent
- Drilled Shaft and Spread Footing Option
# Outline of ABC Drawings

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<th>Standard Sheet Sets</th>
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<td>Precast Abutments, Wingwalls, &amp; Approach Slabs</td>
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<td>P1 – P9</td>
<td>Precast Complete Pier Systems</td>
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<td>S1 – S8</td>
<td>Decked Steel Girder Superstructures</td>
</tr>
<tr>
<td>C1 – C12</td>
<td>Decked Concrete Girder Superstructures</td>
</tr>
<tr>
<td>CC1 – CC32</td>
<td>ABC Erection Concepts</td>
</tr>
</tbody>
</table>
Span Ranges for Superstructures

- Simple / continuous spans from 40 ft to 130 ft.
- Simple for DL; Continuous for LL; No Open Joints
- Plans are grouped in the following span ranges:
  - 40 ft to 70 ft
  - 70 ft to 100 ft
  - 100 ft to 130 ft.
- Spans to 130 ft can usually be transported and erected in one piece at many sites.
- Weight < 200 Kips for erection using conventional cranes commonly used by contractors
Simplified Geometry for ABC

- Constant or no skew
- No flares / no curves
- No superelevation transitions
- Geometric issues better handled on roadway
Prefabricated Decked Beam Elements

- Deck Bulb Tees
- Double Tees
- Composite Steel System
Pre-decked Modular Steel Beams

- Decked steel girders
  - Traditional girder
  - Sub-deck or partial deck top flange
  - Analogous to a bulb tee
Pre-decked Modular Steel Beams

- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Lightweight system for ABC
Pre-decked Modular Steel Beams

- Barrier can be precast
- Barrier load on exterior module
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

Adjacent Double Tee
Geometry Control for ABC

- Construction geometry control for differential camber, skewness, and cross-slope are key to ensuring proper fit up of prefabricated elements and systems.
- Differences in camber between adjacent modules should not exceed 1/4 inch at the time of erection. Otherwise equalizing of cambers to be used.
- Skews cause special problems with decked girders
Integral and Semi-Integral Bridges for Rapid Renewal

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

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

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

• This precast approach pavement consisted of doubly-reinforced concrete panels
• Approach slab supported on precast reinforced concrete sleeper slab.
• Expansion joint may be at backwall or at sleeper slab
• Approach slab longitudinal joints filled with UHPC
• Flooded backfill placed in 1 ft layers
Precast Approach Slab

- Flooded backfill
- Flowable fill under slab
- Exp joint can be moved to sleeper slab
Precast Piers

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

– Ultra High Performance Concrete (UHPC) longitudinal & transverse joints between superstructure modules
– Grouted splice couplers in piers replace the typical lap splice
– Self Consolidating Concrete (SCC) pile connections and abutment to wingwall connections

– Grouted cap pockets / grouted ducts for substructure connections (seismic)
– Other rapid set concrete options may be used
ABC Erection Concepts

Erection Concept Drawings

1. Erection using conventional cranes.

2. Erection using ABC construction technologies adapted from long span construction
Selection of Erection Technology

- The contractor is typically responsible for the development of the erection plans and calculations.
- Erection plan should consider available right-of-way, underground and overhead utilities, capacity of soils.
- The bridge designer can influence the erection technique and potentially bridge erection costs by considering the likely erection methods during the design.
ABC Erection Concepts

• The erection concepts presented in the drawings are intended to assist the designer / contractor in selecting suitable erection equipment.

• Bridges are grouped into:
  – Short spans up to 70 ft;
  – Module weight < 90,000 lbs
  – Longer spans from 70 ft to 130 ft;
  – Module weight < 250,000 lbs
  •
Erection Using Conventional Cranes

- Conventional cranes are part of most contractors field resources.
- Lifts up to 150 kips up to 100 ft pick radius are possible with high capacity conventional cranes.
- Designer should investigate available set up locations for cranes and access for delivery trucks at the site.
- Larger weights will require the use of multiple cranes.
- Erection can be done using land based cranes or cranes supported on barges / causeway.
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
Erection Concepts for Bridge Replacement Using Cranes

Short Single Span over Stream
Cranes selected for 90 Kip pick

Longer Span over Roadway
Weight up to 200 kips
Crane Placement for Erection
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 (LTB)
  - Transverse Gantry Frames
  - Longitudinal Gantry Frames
Above Deck Driven Carriers

• Common form of carrier is the overhead gantry
• Carrier rides over an existing bridge structures and then delivers components
• Allows faster rate of erection
Above Deck Driven Carriers

- Ideal for bridges with many spans, long viaducts
Launched Temporary Bridge

- LTTB’s are launched across or lifted over a span to act as a “temporary bridge”
- Used to deliver the heavier modules without inducing large erection stresses.
- Increases the possibility of erecting longer spans
- LTTB example would be a set of standardized lightweight steel trusses that would be assembled to a specific length that suites a given project.
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.
- Temp bridge can also support transverse gantry frames
Erection Using Gantry Cranes

• Transverse Gantry Cranes
  – Can access all portions of a bridge
  – Can span over traffic

• Longitudinal Gantry Frame
  – Common in segmental construction
  – Can be combined with SPMT for deck replacement
  – Can be used to installed piles, drilled shafts from above
Erection Using Transverse Gantry Cranes
Longitudinal Gantry Frame
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 -- includes instructions to designers so that all the key ABC issues are addressed
- 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 / element size / skew / foundations / etc
- Adapt ABC Special Provisions (specifications) for construction
General Information Sheet

• The general information sheets introduce the intent and scope of the ABC standard plans.
• Lifting and Handling Stresses:
• Shop Drawings and Assembly Plan
• Fabrication Tolerances
• Site Casting Requirements
• Geometry Control
• Mechanical Grouted Splices
• General Procedure for Installation of Modules
GENERAL INFORMATION SUPERSTRUCTURE

THE PREMISES CONSTRUCTION TYPE is to allow for the expansion and contraction of the structure due to temperature changes. The use of expansive joints allows for the building to move without causing damage to the structure. The use of a continuous foundation and the use of reinforced concrete and steel help to prevent the foundation from settling.

THE SYSTEM IS DEPENDENT UPON THE DESIGN STANDARDS CONCERNING THE FOUNDATION. THE FOUNDATION MUST BE DESIGNED TO TRANSFER THE LOADS TO THE SOIL IN A MANNER THAT MINIMIZES THE SETTLEMENT AND PREVENTS THE STRUCTURE FROM SUFFERING DAMAGE.

THE PREMISES CONSTRUCTION SYSTEM SUPERSTRUCTURE: SUPERSTRUCTURE SYSTEMS USED FOR THE SUPERSTRUCTURE SYSTEM INCLUDE CONCRETE, STEEL, AND TIMBER. THE SUPERSTRUCTURE SYSTEMS ARE CONNECTED TO THE FOUNDATION THROUGH JOINTS AND SECTIONS.

SITE CASTING:

IF YOU ARE CONSIDERING CASTING YOUR OWN SUPERSTRUCTURE, IT IS RECOMMENDED TO CONSULT WITH A PROFESSIONAL ENGINEER TO ENSURE THAT THE STRUCTURE IS SAFE AND MEETS THE REQUIREMENTS OF THE STRUCTURAL CODES.

GENERAL INSTALLATION PROCEDURE:

1. SET UP ALL RELEVANT MACHINES IN THE AREA PRIOR TO STARTING THE WORK.
2. COMPLETE ALL REQUIRED SETTINGS AND ADJUSTMENTS PRIOR TO STARTING THE WORK.
3. REVIEW THE PLANS AND SPECIFICATIONS TO ENSURE THAT ALL REQUIREMENTS ARE MET.
4. USE PROPER TOOLS AND MACHINERY FOR THE TASK.
5. PAY ATTENTION TO SAFETY MEASURES AND USE PROPER PERSONAL PROTECTIVE EQUIPMENT.

SAFETY CUTOFF GROOVE TEXTURE FINISH:

SAR CUTOFF GROOVE SUPERSTRUCTURE WITH TOP OF GROOVE DESIGNED TO BE A PARALLEL GAP IDENTITY WITH THE GROOVE...

GEOMETRY CONTROL:

CONSTRUCTION WIDTH, CURVATURE, AND ELEVATION ARE DETERMINED BY THE DESIGNER.

CAMBER CONTROL:

CAMBER CONTROL SHOULD BE CONSIDERED DURING THE DESIGN PHASE TO AVOID PROBLEMS LATER ON.

STANDARD PREFABRICATED

GRUNDSUBSTURKASTE

GENERAL INFORMATION

THE STRUCTURE HALLWAY PROGRAM 2: PROGRAM 2
INNOVATIVE GROUNDSOLUTIONS FOR SAFER ROADWAYS.

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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
INTERIOR MODULE
REINFORCING DETAIL
(SHEAR STUBS OMITTED FOR CLARITY)
(L70 SHOWN; L40, L100 AND L150 SIMILAR)

TRANSVERSE CLOSURE POUR DETAIL
LONITUDINAL CLOSURE POUR DETAIL
(LONGITUDINAL REINFORCEMENT NOT SHOWN FOR CLARITY)
ABC Design Specifications for LRFD

- The *LRFD Design Specifications* do not explicitly deal with the unique aspects of large scale prefabrication.
- In some cases, the most extreme load case may occur during fabrication or shipping and handling.
- The work in SHRP2 R04 entailed the identification of any shortcomings in the current *LRFD Bridge Design Specifications*.
- Recommendations are provided for addressing these limitations.
LRFD for ABC Design

- The design of most ABC elements and systems follows traditional LRFD design specifications.
- Design the ABC elements and the completed structure using all applicable LRFD Limit States.
- Additional requirements apply for ABC connections, lifting and moving of prefabricated elements and modules.
SHRP2 Proposed LRFD Specs for ABC

• Prepare LRFD formatted design and construction specifications based on research

• Address impediments in LRFD Specs to ABC implementation:
  • Loads and Load combinations
  • Construction load cases, Erection stresses
  • Design of connections
  • Design responsibility --- EOR / Contractor’s engineer
  • Prefabrication tolerances, quality, rideability
  • Assembly plans
Loads for ABC Design

- **Construction Loads Unique to ABC** –
  - Loads associated with support conditions during fabrication that may be different than the permanent supports
  - Loads associated with member orientation during prefabrication
  - Loads associated with suggested lift points,
  - Load associated with impact considerations for shipping and handling of components,
  - Loads associated with camber leveling, etc.
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.
Constructibility Checks for ABC Design

- **Constructibility Checks**
  - Evaluation of lifting and erection stresses.
  - What are the limiting stresses / deflections / distortion during transportation and erection
  - Bracing requirements during transportation and erection
Limit States for ABC Design

- **Limit States and Load Factors** during Construction
  - Mandatory Strength limit states -- such as STRENGTH I.
  - What is the appropriate load factor for STRENGTH I loads?
  - Limit state for checking of construction vehicles.
  - Check of critical stability or serviceability effects as the component is moved, assembled, and erected.
  - Requirements for extreme events during construction.
Erection Stresses

• The location of the pick points should be determined so that the unit is picked without roll or stability problems and within erection stress limits

• The Engineer of Record (EOR) is responsible for checking the handling stresses for the lifting locations shown on the plans.

• The Contractor may choose alternate lifting locations with agreement from the EOR.
Proposed ABC Design Specifications for LRFD

- Recommendations are provided for addressing shortcomings in the current LRFD Bridge Design Specifications that may be limiting their use for ABC.
- ABC design incorporates components from several sections of the LRFD code. ABC provisions have been written as if it were to be added as a new LRFD sub section (5.14.6) under Section 5 Concrete Structures.
- Outline of topics given in the next slides.
PROPOSED PROVISIONS FOR DESIGN OF PREFABRICATED SYSTEMS FOR ABC

• 5.14.6.1 General
• 5.14.6.2 Design Objectives
  – 5.14.6.2.1— Rideability
  – 5.14.6.2.2 — Deformations
• 5.14.6.3 Loads and Load Factors
  – 5.14.6.3.1 Definitions
  – 5.14.6.3.2 Load and Load Designation
  – 5.14.6.3.3 Load Factors and Combinations
  – 5.14.6.3.4 Load Factors for Construction Loads
• 5.14.6.4 Analysis
• 5.14.6.5 Control of Cracking (non-Prestressed Components)
PROPOSED PROVISIONS FOR DESIGN OF PREFABRICATED SYSTEMS FOR ABC

• 5.14.6.6 Lifting and Handling Stresses (non-Prestressed)
• 5.14.6.7 Prestressed Components
  – 5.9.4.1—For Temporary Stresses Before Losses
  – 5.9.4.2—For Stresses at Service Limit State After Losses
• 5.14.6.8 Design of the Grouted Splice Coupler
• 5.14.6.9 Provisions for Joints
  – 5.14.4.3.3d—Longitudinal Construction Joints
  – 5.14.4.3.3e—Cast-in-Place Closure Joint
• 5.14.6.10 Provisions for Steel Composite Systems
  – 6.7.4.1 — Diaphragms and Cross frames
  – 6.10.1.1.1a — Sequence of loading
Design Responsibilities

• Under a design-bid-build delivery method, the design services for a prefabricated bridge is performed by different entities.

• The Engineer of Record is responsible only for the bridge in its final support condition.

• Guidance should be developed for engineers involved in ABC alerting them of an increased obligation for strength, stability and adequate service performance prior to final construction.
ABC Design Examples

- In ABC design the careful determination of span arrangement, girder spacings and module dimensions for shipping and erection can add significant savings.
- Detailed ABC design examples provide step by step guidance.
ABC Design Examples

Decked Steel Girder System

P/S Concrete Deck Bulb Tees
Decked Steel Girder Design for ABC

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<th>Organization of Design Examples in the Toolkit</th>
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<td>Closure Pour Design</td>
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</tbody>
</table>

*** Engineer of Record should perform own ABC design ***
Decked Steel Girder Design for ABC

• Three Stages for Design

Prefabrication Stage (many support options)
– Load Case 1 = Dead load on module steel section only
– Load Case 2 = Dead load on module composite section

Erection Stage (many lift options)
– Load Case 3 = Modules are lifted into place

Final Stage
– Load Case 4 = Modules are assembled and made continuous
  » DL
  » FWS
  » LL + IM
  » Utilities
Decked Steel Girder Design for ABC Erection Stage

• Erection Loads
  – Analysis for pick points / supports shown on plans
  – Contractor may select other erection method and do own erection analysis

• Erection Limit State
  – Load Factor for erection dead Loads
  – IM for dead loads

• Erection Stresses
  – Flexural stresses < Allowable
Decked Prestressed Concrete Girder Design for ABC

• 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.

• Consult local suppliers for the project, but as a rule of thumb, limit shipping weights to 200 kips.
## ABC Design Example – Deck Bulb Tee

### Organization of Deck Bulb Tee Design Example

<table>
<thead>
<tr>
<th>General:</th>
<th>Concrete Stresses at Release</th>
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<td>Design Philosophy</td>
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<tr>
<th>Girder Design:</th>
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<td>/ Erection / Final</td>
</tr>
</tbody>
</table>

*** Engineer of Record should perform own ABC design ***
Decked Prestressed Concrete Girder Design for ABC

• Three Stages for Design

  *Transfer Stage*
  – Load Case 1 = Dead load of decked girder

  *Erection Stage*
  – Load Case 2 = Decked girder is lifted into place

  *Final Stage*
  – Load Case 3 = Modules are assembled and made continuous
    » DL
    » FWS
    » LL + IM
    » Utilities
Decked Prestressed Concrete Girder

Limits on Concrete Stresses for ABC

• 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

• Use appropriate concrete strengths
Concrete Tensile Stresses at Erection

- No cracking during transportation and erection for the lift points selected
- Limited tension to modulus of rupture with a F.S = 1.5
- 30% Impact
- Calculate the concrete stresses for the effective prestress force using only the losses between transfer and erection
Decked Prestressed Concrete Girder Camber Control for ABC

- Control of differential camber between adjacent girders at the time of erection is key to proper fit up in the field.
- Girder cambers have to meet specified tolerances for casting of closure pours and achieving deck smoothness.
- All aspects of the fabrication process should be as uniform as possible for each girder. Schedule fabrication so that camber differences between adjacent girders are minimized.
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.

- Camber leveling forces cause additional tension in the bottom fiber.
Decked Prestressed Concrete Girder
Limits on Concrete Stresses for ABC

• ABC design of precast prestressed girders follow the LRFD provisions with a few additional considerations
• Concrete tension in the bottom fiber at final, SERVICE III, is limited to 0.0 ksi for ABC design
• Imposing this limitation precludes the need to evaluate the tensile stresses from camber leveling forces
• This is a departure from LRFD
Proposed ABC Construction Specifications for LRFD

• Recommended ABC construction specifications pertain specifically to prefabricated elements and modular systems.

• Focus heavily on means and methods requirements for rapid construction using prefabricated modular systems.

• Much of these provisions reflect a compilation of best practices for ABC construction and lessons learned.

• A bridge owner using these specifications as a guide could develop their own Special Provisions for an ABC project.
Proposed ABC Construction Specifications for LRFD

Recommended Special Requirements for ABC

Proposed Section in LRFD Construction Specifications

XX.1 GENERAL
XX.2 RESPONSIBILITIES
XX.3 MATERIALS
XX.4 FABRICATION
XX.5 SUBMITTALS
XX.6 QUALITY ASSURANCE
XX.7 HANDLING, STORING, AND TRANSPORTATION
XX.8 GEOMETRY CONTROL
XX.9 CONNECTIONS
XX.10 ERECTION METHODS
XX.11 ERECTION PROCEDURES
ABC Construction Specifications

• The specification identifies responsibilities for design, construction and inspection during an ABC project.
• Fabricator qualifications, requirements for plant casting and site casting are defined.
• It identifies two phases of inspection: fabrication inspection and field inspection that are the responsibility of the owner.
• Quality control and geometry control of components are identified as key parts of ABC construction.
• Requirements for various connection types commonly used in ABC, including UHPC joints, are defined.
QUESTIONS ?
Accelerated Bridge Construction
ABC
Bala Sivakumar
HNTB Corp.
New York
Session 3

ABC Pilot Projects
Outline

• Introduction
• Pilot Project #1 – PBES (Iowa)
• Pilot Project #2 – Lateral Slide (NY)
• Lessons Learned
SHRP2 R04 ABC Pilot Project #1
Prefabriicated Elements (IADOT)

Oct 17, 2011
14 Day ABC Period

Keg Creek Bridge

Nov 1, 2011
SHRP2 R04 ABC Pilot Project #2
Lateral Slide (NYSDOT)

- Nov 2012 letting
- 2012-2013 Construction
- Overnight replacement

I-84 EB & WB Bridges
over Dingle Ridge Road
ABC Pilot Project #1
US 6 Bridge over Keg Creek
Council Bluffs, Iowa

- 3 Span bridge; Spans: 67’-3”, 70’-0”, 67’-3”
- IADOT Design -- Conventional Construction
  - 6-month closure
  - ADT = 4000; 14 mile detour
- Selected by IADOT as ABC candidate
- Redesigned for ABC by SHRP2 R04 Team
  - Modular construction
  - 14 day ABC period (Road closure)
- Project needed to fit timing for R04 project
- Highway / civil design by IADOT
Bids
Keg Creek Bridge, Iowa

- Seven local bidders
- Contract letting: Feb 2011
- Contractor: Godbersen-Smith Construction, Ida Grove, IA
- Low Bid: $2.67 Million (bridge & approach works)
- Bridge cost = $231 / SF
- Incentive / Disincentive = $ 22000 / day during 14 day ABC period
- HFL funds $600,000; SHRP2 funds $250,000
US 6 Keg Creek Bridge
Site Layout

On-Site Prefabrication Yard

Bridge
Keg Creek Bridge -- ABC Design

– Entire bridge built with prefabricated elements and modular systems

– Decked steel beam modules; Simple for DL; Continuous for LL

– Only the 6’ dia. drilled shafts were cast in place prior to closing the existing bridge

– Contractor could self-perform concrete precasting or have it done by a precasting plant

– Size and weight to allow erection with conventional cranes (< 200 Kips)
Local Prefabricator Capabilities

• In the Iowa demonstration project, the local precasters would not produce deck bulb-tees without expensive form modifications
• A prefabricated modular system was the economical choice for this site
• Plans allowed the contractor to propose a concrete option as a value engineering alternate. None was proposed.
Cross-Sections / Plan

End Dam for UHPC Joints

UHPC Joints
ABC Design Highlights

- Complete prefabricated bridge elements, including approach slabs
- On-site precast fabrication
- UHPC, SCC, Grouted splice coupler connections for rapid field assembly
- HPC concrete. No open joints
- First bridge in US with full, moment-resisting UHPC transverse joints at the piers
- Semi-integral abutment for rapid superstructure construction
- Flooded backfill for rapid substructure construction
Three Construction Stages

Stage 1 work (pre ABC period):
- Construct drilled shafts to ground level
- Pre-fabricate modules in staging area.

Stage 2 work (during 14-day ABC period)
- Detour traffic & demolish existing bridge
- Assemble precast piers & abutments
- Assemble modular superstructure & precast approach pavement
- UHPC closure joints / grind deck / re-open bridge

Stage 3: Post ABC -- Complete channel works / slope protection (20 days)
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’ dia. 75 ft long)
Prefabrication Yard (Pre-ABC)

Iowa Bridge Farm

- Bottom mat of deck reinforcing nearly complete
- Column sections cast and curing
- Rebar cage for next column section
- Abutment and wingwall components complete

Sept 30
Project Schedule

• 14-day ABC period:
  – Oct 17\textsuperscript{th} to Nov 1, 2011

• Pre-closure fabrication during Summer 2011
  – Drilled shafts installed
  – Fabrication of superstructure modular units
  – Fabrication of substructure elements
Prefabricating the Modular Beam Elements

- ALL UNITS ARE FABRICATED AWAY FROM TRAFFIC SUPPORTED SIMILAR TO THEIR FINAL ERECTED CONDITION
- All formwork for the deck shall be supported from the longitudinal girders similar to conventional construction (unshored construction – future deck replacement possible)
Prefabircation of Abutments and Piers
Prefabricating the Modular Beam Elements

- Steel was fabricated in the shop
- The deck concrete was cast on-site
- Contractor chose to prefabricate modules in their exact relative location
Stage 2 (ABC Period)
Rapid Demolition

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

Day 1
Oct 17
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
Precast Wingwalls Assembly

Self Consolidating Concrete Joints
Precast Piers – Straddle Bents

Days 4 & 5

Grouted Splice Couplers

RCC Design

Voids in Cap Beam
Grouted Splice Coupler

- Use in low seismic areas only
- Drilled shaft to column connections
- Column to cap connections
- Fast assembly
Precast Columns

Template for Dowels
Precast Pier Assembly

- Pier caps - 168 kips.
- Required two 110-ton cranes to lift into position.
Prefabriacating the Modular Beam Elements

- 6 Decked Steel Girder Modules
- Non-proprietary
- Beam spacings were selected for ABC. There are other wider spacing options that could be used.
Erection of the Modular Beam Elements

Days 7 & 8

Span = 70 ft
Erection of the Modular Beam Elements

Days 7 & 8
Semi-Integral Abutment
Suspended Backwall

- Allows superstructure expansion / contraction
- Easy fit up
- Well suited for rapid construction
UHPC Joints in Bridge Deck

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

(Longitudinal Joint)
Transverse UHPC Joints at Piers

- UHPC joint reinforced to carry the full LL tension
- First use of UHPC for transverse joints over pier
Transverse UHPC Joints
Lab Tests at Iowa State University (Pre ABC)

- Assess strength and serviceability of the transverse joint
- Determine ultimate moment capacity
- Tests show good correlation with design strength
- Identified HPC deck cracking & bond issues
Transverse Joint Serviceability Design

- 1 inch H.S threaded bar post-tensioned to 70 Kips
- PT force such that the extreme fiber of the deck concrete to remain below a zero-tension condition during live load to prevent deck cracking under service loads
Precast Approach Slab

Day 10

Precast Sleeper Slab
Flooded Backfill
Deck Riding Surface

- No open deck joints.
- Integral wearing surface --- overlay not required.
- Extra ½ inch for grinding for smooth riding surface
- Longitudinal grooving for skid resistance.
Nov 1, 2011

Keg Creek Video: One Design—10,000 Bridges

SHRP2 Website
Time Lapse Video

• keg Creek Time Lapse Video (3 min)
Highways for Life Workshop

- Held on Oct 28th
- 80 attendees from 14 states
- Site visit on day of UHPC pour
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 & follow procedures. Bond between UHPC and deck is critical.
- UHPC reinforcement should allow joints to be more easily and quickly constructed. Straight bars preferred.
Second ABC Pilot Project
I-84 Bridges over Dingle Ridge Road
Lateral Slide

- 50 miles north of New York City
- NYC watershed area
- Over 75,000 to 100,000 ADT
- Major truck route
- Exist 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
  - Take one construction season for each bridge
I-84 New York

Existing Twin Bridges
I-84 Bridges New York
Existing Bridges

- Three simple spans: 37’: 55’: 42’
- Two lanes @ 12 ft
- Two shoulders @ 2’
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
Traffic Control During Construction

- Traffic on I-84 will be maintained during substructure work.
- Detour will be in place for only 16-18 hours for the removal of existing bridge and slide in of the new.
- Detour during Saturday night -- Sunday morning.
- Route 6/202, parallel to I-84, will be used as the detour.
ABC Design - New Bridges

• Single span 80’; Three lanes at 12’
• Left shoulder 6’, right shoulder 12’
• Bridge width 33’-4” $\rightarrow$ 57’-0”
• Provides room for future traffic control
• Use 3” asphalt wearing surface eliminates grinding
• Under passing Dingle Ridge Road on 15.7% grade
• New bridges will be about two feet higher than the existing to provide under-clearance.
• Need to minimize new structure depth
ABC Design Challenges

• Need to raise I-84 approaches as much as 2 feet during ABC window to satisfy under-clearance.
• Removal of asbestos from existing abutment backwalls
• Existing abutments on fill with spread footings --- need to minimize disturbance during substructure construction
Typical Sections

- New bridge is wider
- Construct abutment drilled shafts outside footprint
- NEXT beam (double T beam) superstructure
- Precast approach slabs
New Straddle Bent Abutment & Wingwalls

Abutment Section
Straddle Bent Abutment w/ modular retaining walls
End Diaphragm

Slide Shoe
Slide Shoes

PTFE Bonded to Elastomeric Pad
Lateral Slide Using Jacks
Longitudinal Elevation

During Slide

- Slide Surface
- Temp. jump span

Final (complete modular walls after reopening)

Modular walls
Sleeper Slab / End Dam

End dam will retain the approach pavement that will be raised by 2 ft during ABC period.
<table>
<thead>
<tr>
<th>TIME</th>
<th>BRIDGE ACTIVITY</th>
<th>MAXIMUM ANTICIPATED DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 PM SATURDAY</td>
<td>ROUTE TRAFFIC TO ROUTE 6</td>
<td>8 HRS</td>
</tr>
<tr>
<td>5:00 PM SATURDAY</td>
<td>REMOVE DECK FROM EXISTING BRIDGE</td>
<td>2 HRS</td>
</tr>
<tr>
<td>7:00 PM SATURDAY</td>
<td>PLACE SLEEPER SLABS AND COMMENCE APPROACH WORK</td>
<td>2 HRS</td>
</tr>
<tr>
<td>1:00 AM SUNDAY</td>
<td>REMOVE STEEL GIRDERS FROM EXISTING BRIDGE</td>
<td>2 HRS</td>
</tr>
<tr>
<td>3:00 AM SUNDAY</td>
<td>REMOVE SUBSTRUCTURE TO ELEVATION BELOW ELEVATION OF Sdio</td>
<td>4 HRS</td>
</tr>
<tr>
<td>7:00 AM SUNDAY</td>
<td>SLIDE IN NEW BRIDGE</td>
<td>4 HRS</td>
</tr>
<tr>
<td>11:00 AM SUNDAY</td>
<td>OPEN BRIDGE TO TRAFFIC</td>
<td>18 HRS</td>
</tr>
<tr>
<td>5:00 PM SATURDAY</td>
<td>ABC TIMEFRAME</td>
<td></td>
</tr>
<tr>
<td>TO 11:00 AM SUNDAY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. ABC TIMEFRAME

C1. THERE SHALL BE TWO EQUAL ABC TIME FRAMES, ONE FOR THE REPLACEMENT OF THE EASTBOUND BRIDGE AND ONE FOR THE REPLACEMENT OF THE WESTBOUND BRIDGE. THESE ABC WINDOWS SHALL OCCUR ON SEPARATE WEEKENDS, COMMENCING ON SATURDAY SEPT 7, 2013 NIGHT AND EXTENDING THROUGH SUNDAY SEPT 8, 2013 MORNING. THEY COULD BE DONE ON SUCCESSIVE WEEKENDS AS APPROVED BY NYSDOT.
Pre ABC Period
Construct abutments, new superstructure
ABC Period
Detour, Demolish Existing Bridge
ABC Period
Slide In New bridge, Raise Approaches, Reopen
Post ABC Period
Construct modular walls, Complete approach widening
Both Bridges Completed
Two weekends (Sept 2013)
ABC Benefits

• **Road Closure** will be significantly reduced from two construction seasons to two weekends.

• **Safety** within the work zone will be improved.

• **Reduced Costs**: primarily by not building the crossovers and temporary bridge in the median ($2.0 M savings).

• **Impacts to the New York City watershed** will be substantially reduced; at least 5 acres of land will not have to be disturbed with the ABC.

**ABC is the clear choice**
QUESTIONS ?