PRESENTATION OBJECTIVES

• Discuss project concept
• Share preliminary construction details (60% plans)
• Solicit feedback from Workshop participants
• Precursor to upcoming meeting with Iowa Association of General Contractors
PROJECT OVERVIEW

OBJECTIVE: In-House Design of ABC Bridge using PBES (Non-Slide)

SITE: IA-92 over Little Silver Creek
West of Treynor, IA (Rural)

GEOMETRY: 234’ x 44’ Bridge, 20° Skew, Sag Vertical Curve

SCHEDULE: Road Closure Limited to 21 Days

LETTING: December 16, 2014

CONSTRUCTION: Fall, 2015

EST. COST: $3.2M

STATUS: 60% Design Plans as of May 1, 2014
Existing 150’-0 x 28’ Continuous Conc. Girder Bridge
WATERWAY OPENING, SPAN 2, LOOKING UPSTREAM
2/4/10

Looking North
UPSTREAM CHANNEL FROM PIER 1
2/4/10

Looking North
Looking South

DOWNSTREAM CHANNEL FROM MID SPAN 2
2/4/10
Existing 150’-0 x 28’ Continuous Conc. Girder Bridge
SITE OBSTACLES

• Skew
  – Iowa has not previously applied decked module concept to skewed bridge

• Sag Vertical Curve
  – 4.0% deck grade at W. Abutment, 2.7% at Pier 1
  – Sag curvature complicates fit-up, requires more accuracy during fabrication/prefabrication

• Poor Soil Conditions
  – Long pile lengths with 2 or 3 field splices per pile

• Long Unbraced Length at Piers
  – Degraded channel plus design scour
  – Unsupported length exceeds Iowa design standards for pile bent piers
DESIGN STATUS

• Design Team
  – Curtis Carter
  – Mike Nop
  – Dean Bierwagen

• Design/Details under development, 60% complete

• Design concept may evolve based on:
  – Feedback from ABC Workshop
  – Feedback from Iowa Association of General Contractors
  – Possible research opportunities
DESIGN HIGHLIGHTS
CONCEPT

• **Superstructure**
  – Modular Decked Beams

• **Substructure**
  – Integral Abutments
  – Pile Bent Piers

• **Details intended to:**
  – Build on Proven Technology
  – Improve Accelerated Constructability
  – Ease Construction Tolerances
  – Facilitate Rapid Field Adjustment
  – Satisfy Performance Goals (Construction Schedule, Design Life)
  – Promote Contractor Involvement and Innovation
ACCELERATED CONST. SCHEDULE

21-DAY ROAD CLOSURE

• **Pre-closure activities:**
  – Prefabricate superstructure modules
  – Prefabricate substructure caps/footings (optional)

• **During closure:**
  – Demolition
  – Grading and Revetment
  – Substructure Construction
  – Superstructure Construction
  – Approach Construction

• **Post-closure activities (permissible single-lane closures as required):**
  – Shoulder Construction
  – Guardrail
  – Finish Grading and Seeding
  – Miscellaneous Non-Structural Construction Activities
PROPOSED CONST. PHASING

**PHASE I**
- Close existing bridge to traffic

**PHASE II**
- Demolish existing bridge
  - Install pile
  - Install abutment & pier beam seats

**PHASE III**
- Install decked beam modules

**PHASE IV**
- Construct abutments
- Construct monolithic deck closure at piers

**PHASE V**
- Construct longitudinal deck closures
- Construct barrier rail
- Construct approaches (not shown)

**PHASE VI**
- Open new bridge to traffic

CONSTRUCTION PHASING DIAGRAM
# Proposed Schedule

## 21 Day ABC Timeline

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MODULAR DECKED BEAMS

2-BEAM MODULAR UNITS

- Patterned after US-6 over Keg Creek
- ± 100,000 lbs Module Weight
- W40x149 Beams (Simple Span)
  - Prestressed concrete beams were considered but not implemented due to geometry complications (camber vs. grade) and heavier pick weights
- 4’-6 Beam Spacing, 7’-0 Deck Width
- 8¼” High Performance Concrete Deck
  - Deck includes additional sacrificial thickness to allow grade/crown adjustment by grinding
- Stainless Steel Deck Reinforcing
  - Improved joint performance and greater service life

Typ. Module Detail

Transverse reinforcing will project from module for staggered lap with adjacent module

Bottom of beams will be set level; crown will be established using variable haunch thickness
MODULAR DECKED BEAMS

- Six-module cross section
- 10" joint between modules
- Discontinuous steel diaphragms
MODULAR DECKED BEAMS

18-module deck
MODULAR DECKED BEAMS

Beam ends project from modular deck for lifting and securing to other modules.
ALTERNATE SITE CASTING

• Due to complex geometry, accurate prefabrication of single individual modules at a fabrication shop/casting yard will likely be difficult and expensive.

• The recommended prefabrication procedure consists of using alternate site casting procedures to construct all modules simultaneously on temporary supports that match the relative location/elevation of the design bridge seats.
  — Constructing modules simultaneously in the correct relative position facilitates accurate bar placement (optimized bar stagger at longitudinal joints).
  — Minimizes post-assembly grinding/grade correction due to misaligned joint mating surfaces.
  — Deck joint locations could be blocked out to allow for concrete placement using a conventional paving machine.
  — Alternate site would be selected by the contractor and would be close to the project site, minimizing module transportation costs.
ALTERNATE SITE CASTING

Profile grade scale exaggerated 5X

MODULE CASTING NOTES:
The contractor shall be required to submit a module casting plan for review and approval by the engineer. The module casting plan shall include, but shall not be limited to the following:

- Casting site location
- General overview of casting operations
- Description of temporary supports
- Quality control and geometric centerline measurements required to ensure the casting will meet the required tolerances
- Proposed schedule including minimum downtime periods for welding, stripping, transporting, and loading of precast components

The contractor is strongly encouraged to utilize frame casting operations for as many absolutely possible. The contractor is responsible for all precast components that are fabricated, transported, and installed. The contractor is required to provide all mechanical, electrical, and other services necessary to complete the project.

The following is a suggested casting procedure for construction of the deck module:

- Position all structural steel frame components for each module, keeping the cast-in-place temporary supports located at designated locations for accurate placement of the modular units during casting of the deck sections.
- Position temporary supports for the deck, including the existing support conditions, temporary support conditions, and the relative locations and alignment of the modular units during casting of the deck sections.
- Position temporary supports for the deck, including the existing support conditions, temporary support conditions, and the relative locations and alignment of the modular units during casting of the deck sections.

Alternate casting procedures may be submitted by the contractor for review.

Design and safety of any temporary supports required shall be the responsibility of the contractor. Temporary supports shall remain in the property of the contractor and all temporary supports shall be removed by the contractor prior to completion of the project.

All costs associated with construction of precast concrete modules, including temporary support and transportation of precast concrete modules, shall be included in the individual bid for the superstructure module.
C.I.P. TRANSVERSE JOINTS

CONVENTIONAL CAST-IN-PLACE TRANSVERSE JOINTS

- Wider joint for improved constructability
- Allows joint(s) to be placed at lower-stress regions of deck
- Deck closure concrete is monolithic with abutment/pier diaphragms
- Conventional construction procedures with concrete maturity monitoring
ULTRA-HIGH-PERFORMANCE CONCRETE

• **Performance Advantages**
  – Better bond with precast module concrete
  – Improved durability compared with conventional concrete
  – Reduced development lengths for narrower joints
  – Placed after C.I.P. transverse closures to minimize UHPC forming requirements

• **Design Considerations**
  – Limited contractor experience
  – Special construction procedures
  – On-site test pour will be required
  – Contractor will be required to coordinate with manufacturer and follow recommended procedures

**Example Deck Joint Options**

**Version of this detail used for design**
SIMPLE-MADE-CONTINUOUS

- Designed to support dead load and live load for simple span conditions
- Details will be implemented to allow structure to behave as continuous under live load
  - Additional deck reinforcing in negative moment region
  - Steel block used to transfer compressive forces between beam bottom flanges

Snug-fit acceptable for compression detail

Monolithic diaphragm encases full moment reaction

Slotted holes and shim packs facilitate constructability and field adjustment

Proposed Pier Continuity Details
MODULAR SUPERSTRUCTURE

- Deck end section cast integrally with abutment diaphragm
- Staggered bar lap for transverse joints
MODULAR SUPERSTRUCTURE

Wide transverse deck closure integral with pier diaphragms

Compression block assembly
PILE BENT PIERS

- Selected for economy/constructability
- Design considerations include scour and unsupported length
  - HP16x141 Piling (first use of HP16 section in Iowa)
  - Piling oriented for strong-axis bending (non-standard detail in Iowa)
- Design intent to include multiple construction options:
  - Precast cap option
  - Cast-in-place cap option
  - Option to construct concrete pile encasement after critical road closure
- C.I.P. diaphragm monolithic with deck
  - Provides simple and durable connection of deck modules at pier
PILE BENT PIERS

PIER NOTES:

BRIDGE PIERS FOR THIS PROJECT SHALL CONSIST OF TYPE A OR TYPE B PIERS AS DETAILLED IN THESE PLANS, THE SELECTED PIER TYPE SHALL BE THE SAME FOR PIER 1 AND PIER 2.

PILE DESIGN AND CONSTRUCTION CONTROLS REQUIREMENTS SHALL BE THE SAME FOR TYPE A AND TYPE B PIERS. REFER TO PILE NOTES AND PIER PILE TABLES.

CONSTRUCTION OF PILE ENCLOSURES SHALL BE PERMITTED AFTER PLACEMENT OF THE PILE CAPS. THE CONTRACTOR SHALL BE REQUIRED TO SUBMIT A "TEMPORARY SUPPORT PLAN FOR PILE CAPS" THAT ARE TO BE CONSTRUCTED PRIOR TO FULL MASTERY OF THE PILE ENCLOSURE CONCRETE STRENGTH AND AT THE REQUEST OF THE ENGINEER. FIELD WELDING OF BRACKETS TO THE PILES SHALL BE DISABLED AS A MEANS OF "TEMPORARY PIER CAP SUPPORT.

MINIMUM CLEAR DISTANCE FROM FACE OF CONCRETE TO REINFORCING BAR IS TO BE 2 INCHES UNLESS OTHERWISE NOTED ON SHEET.

REINFORCING IS TO BE SECURELY WIRE IN PLACE BEFORE CONCRETE IS Poured.

THE LUMP SUM PRICE BID FOR "PILE POLE PIER" SHALL INCLUDE ALL COSTS OF MATERIALS AND LABOR FOR CONSTRUCTION OF PILE CAPS AND PILE ENCLOSURES INCLUDING, EXCAVATION, CAST-IN-PLACE AND PRECAST STRUCTURAL CONCRETE, FORMS AND CONCRETE PLACEMENT, MECHANICAL STEEL, STRUCTURAL STEEL, AND TEMPORARY SUPPORTS AS REQUIRED.

MATERIALS AND LABOR FOR STONE PILES SHALL BE INCLUDED IN THE PRICE BID FOR "PILE STEEL, HP 16 X 14".

PIER NOTES:

THE CONTRACT LENGTH OF THE PIER PILES IS BASED ON THE DESIGN PARAMETERS LISTED IN THE "PIER PILE DESIGN LRF" TABLE.

THE REQUIRED NON-TEAR AXIAL RESISTANCE FOR ANCHORED PILES AT END OF WORK IS BASED ON THE PARAMETERS LISTED IN THE "PIER PILE DESIGN LRF" TABLE.

PIER PILES SHALL BE BRAVE LUMP SUM DESIGN DESIGNE IS ADJUSTER AND THE PILES EXCEED THE WASHOUT PENETRATION DEPTH NOTED IN THE PLANS. THESE REQUIREMENTS SUPERDISE THE REQUIREMENTS NOTED IN SECTION 10.2.2.3. OF THE STANDARDS SPECIFICATION. CONSTRUCTION CONTROL, REQUIRES A MEAN ANALYSIS WITH BEARING CAPS.

PIER PILE DESIGN (LRF)

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PIER PILE CONST. CONTROL (LRF)

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EST. QUANTITIES - TWO BRIDGE PIERS

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PIER DETAILS - GENERAL

STA. 234'-0" TO 244'-0" ROLLED STEEL BEAM BRIDGE

W/1'-0" & L/1'-0" END SPANS & W/1'-0" CENTER SPAN

PIER DETAILS - GENERAL

STA. 234'-0" TO 244'-0" ROLLED STEEL BEAM BRIDGE

W/1'-0" & L/1'-0" END SPANS & W/1'-0" CENTER SPAN

POTTAWATTAMIE COUNTY

PROJECT NUMBER: 200-005-06-10-03-78

SHEET NUMBER: 11
PILE BENT PIER (C.I.P. CAP)

Conventional construction; forms and reinforcing cage preassembled and dropped into place, concrete maturity after 24-36 hrs.

Pile encasement is non-structural for design; may be constructed after critical road closure.
PILE BENT PIER (PRECAST CAP)

Lifting loops (± 125,000 lbs. pick weight)

CMP pile pockets
INTEGRAL ABUTMENTS

- Selected for constructability/durability
- Design considerations include stability during module placement
  - Prebored piles oriented for weak axis bending
  - Desire/need for piles to be braced during module placement
- Design intent to include multiple construction options
  - Precast cap option
  - Cast-in-place cap option
  - Capless option (beams supported directly on piling)
- C.I.P. diaphragm monolithic with deck
  - Provides simple and durable connection of deck modules at abutment

Integral Abutment with Precast Cap
INTEGRAL ABUT. (PRECAST/C.I.P.)

± 95,000 lbs. pick weight

CMP pile pockets (omit for C.I.P. option)
INTEGRAL ABUT. (PRECAST/C.I.P.)

Abutment backwall monolithic with end of deck

Mechanical splicers connect footing and backwall
Concept has not been used on in-house IA DOT bridge designs, but other states have positive experience with this method.

Concept is being considered as an option for this project, although Iowa is soliciting input/feedback from contractors and other states.

Possible advantages for this project:
- Removes abutment footing construction from the critical path for deck module placement
- Could facilitate accurate placement of beam seats
- More conservative design, but not necessarily more expensive

Design considerations:
- Applicability to modular ABC concept?? Construction Tolerance?? Can these details be constructed quickly and accurately??
- Pile stability during module placement?? Module dead load reactions could exceed typical dead load reactions of single beams.
- Pile bracing details??
- Field welding concerns??
ABUTMENT CONCEPT: BEAM-ON-PILE

(1) INSTALL PILING
ABUTMENT CONCEPT: BEAM-ON-PILE

(2) INSTALL BRACING & BEAM SEATS
ABUTMENT CONCEPT: BEAM-ON-PILE

(3) INSTALL PRECAST WINGS
ABUTMENT CONCEPT: BEAM-ON-PILE

(4) INSTALL DECKED MODULES & WING POCKETS
ABUTMENT CONCEPT: BEAM-ON-PILE

(5) PLACE ABUTMENT CONCRETE
ABUTMENT CONCEPT: BEAM-ON-PILE

(6) PLACE UHPC LONGITUDINAL JOINTS
ABUTMENT CONCEPT: BEAM-ON-PILE

(7) INSTALL BARRIER RAIL
INTEGRAL ABUT. (BEAM-ON-PILE)

Requires more piles than Precast/CIP option, but shorter lengths.

Pile bracing between modules
INTEGRAL ABUT. (BEAM-ON-PILE)

Abutment, wings and deck closure poured together
PROJECT OBJECTIVES

• Safe structure (during construction and service) with long service life
• Accelerated construction schedule
• Demonstrate application of modular construction concept at a more challenging site
• Demonstrate improvements upon previous experience with the modular construction concept
• Provide in-house design experience
  – Provides designers with a better understanding of the unique design/details/processes required for the modular construction concept, and for ABC projects in general.
  – Experience will benefit in-house designers of similar projects, and reviewers of consultant-designed projects.
• Expand agency experience
  – When combined with experience from the Keg Creek project, IA DOT can develop a better understanding of the costs, benefits, and limitations of the modular construction concept.
  – Experience with this project will assist the DOT in establishing policy and selecting the appropriate construction concept (modular construction, slide, etc.) for future ABC projects.
• Integral abutments
  – Iowa’s preferred abutment type, but hasn’t previously been applied to ABC project

• Transverse deck closures monolithic with beam end diaphragms
  – Moves joint interface to lower-stress region of deck, provides secure connection of modules

• Simplified UHPC joint details
  – Wider joint, simpler bar lap, less bar congestion
  – UHPC application to longitudinal joints only should simplify forming

• Simplified continuity details
  – Faster construction, more liberal construction tolerance
PROJECT INNOVATIONS (IOWA PERSPECTIVE)

• Stainless steel deck reinforcing
  – New to Iowa, expected to provide better joint performance and longer service life

• Expanded application of pile bent piers
  – Long unbraced length requires larger pile size

• Fully detailed design alternates for substructure
  – Facilitates contractor involvement in the final design solution

• Greater opportunity/application of accelerated cast-in-place concrete
  – Counter-intuitive to some ABC philosophy, cast-in-place concrete can be a good design option if it can be placed quickly and accurately
  – Cast-in-place concrete is generally more forgiving than precast concrete with respect to construction tolerance
# SCHEDULE, REVISITED

## 21 Day ABC Timeline

| CONSTRUCTION ACTIVITY                              | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| CLOSE IA 92                                       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |
| BRIDGE DEMOLITION                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| GRADING & RIP-RAP PLACEMENT UNDER BRIDGE          |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| DRIVE PIER PILING                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| PIER PILE ENCASEMENT CONSTRUCTION                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| DRIVE ABUTMENT PILING                             |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| CONSTRUCT PIER CAP                                |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| ABUTMENT PILE BRACING & BEAM SEATS                |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| ERECT DECK MODULES                                |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| CONSTRUCT ABUTMENTS & WINGS                       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| CONSTRUCT PIER CAP DIAPHRAGMS                     |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| PLACE UHPC LONGITUDINAL JOINTS                    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| CONSTRUCT APPROACHES AND BARRIER RAIL             |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| GRINDING & LONGITUDINAL GROOVING OF DECK          |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| FINISH GRADING & WING ARMORING                    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| GUARDRAIL & PAINT                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| OPEN IA 92                                        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
SCHEDULE, REVISITED

• DEMOLITION & GRADING – 4 DAYS
• PIERS – 7 DAYS
• ABUTMENT SEAT – 5 DAYS
• MODULE PLACEMENT – 3 DAYS
• TRANSVERSE CLOSURES – 3 DAYS
• UHPC JOINTS – 1 DAY
• APPROACHES – 3 DAYS
• BARRIER RAIL – 2 DAYS
• DECK GRINDING/GROOVING – 2 DAYS
WORKSHOP DISCUSSION OPPORTUNITIES

Opportunities for improvement??

• Schedule
• Decked module concept
• Transverse joint concept
• Longitudinal joint concept
• UHPC details
• Continuity details
• Pier details
• Abutment details
• General constructability
QUESTIONS??

THANK YOU!!