Iowa ABC Demonstration Project; US 6 over Keg Creek



2017 NCPA Workshop – Lincoln, NE

Presented By David Evans, PE - Iowa DOT

HNTB

HIGHWAYS FOR LIFE

BRIDGE ENGINEERING CENTER

U.S. Department of Transportation
Federal Highway Administration

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

Iowa Department of Transportation

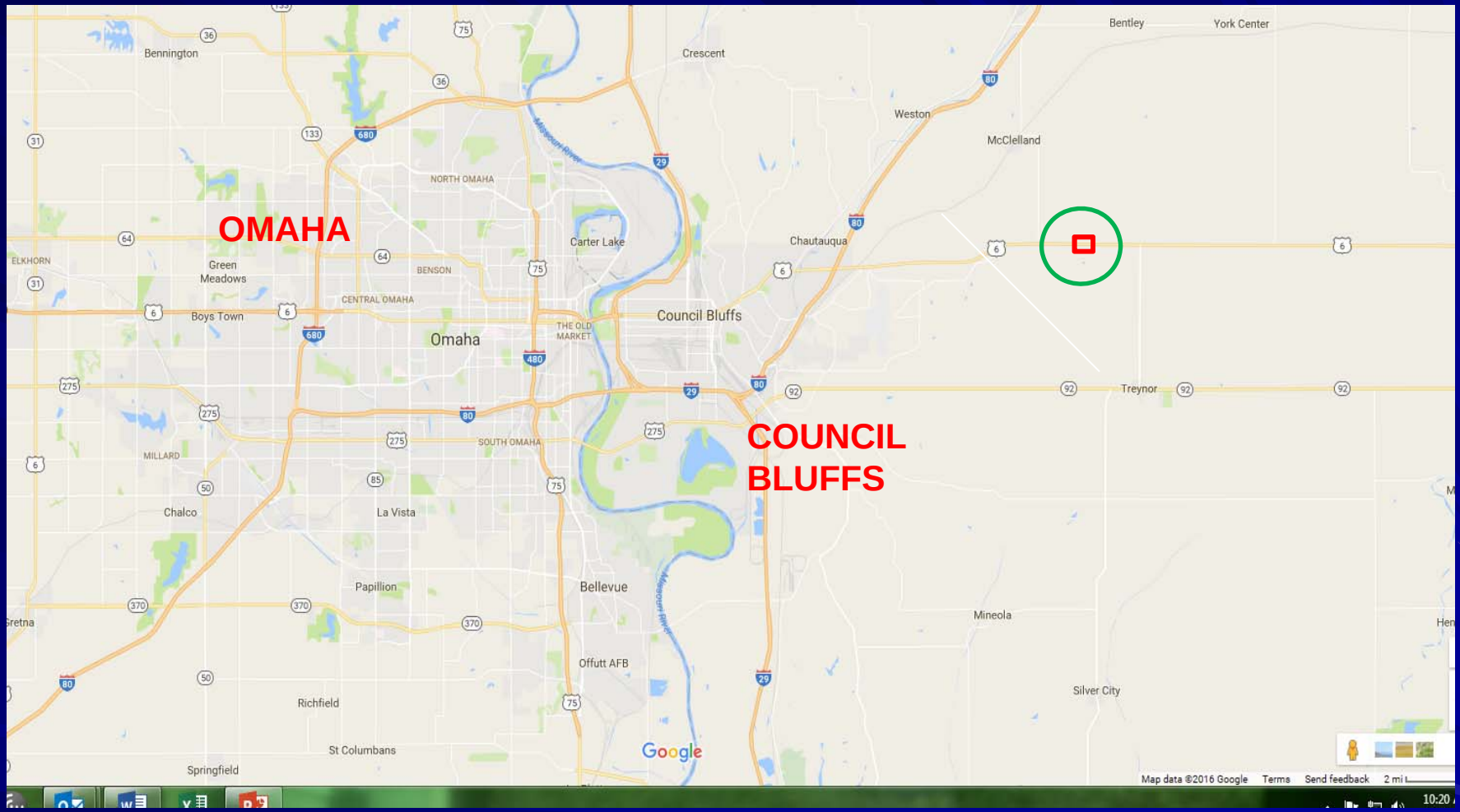
Why ABC?

- Rapid renewal of transportation infrastructure.
- Minimize construction impacts on customer mobility. (i.e. shortened closure periods enhances customer convenience and reduces user costs)
- Increased safety for the public and contractor. (i.e. reduced closure periods and no staged construction)

Background – Keg Creek

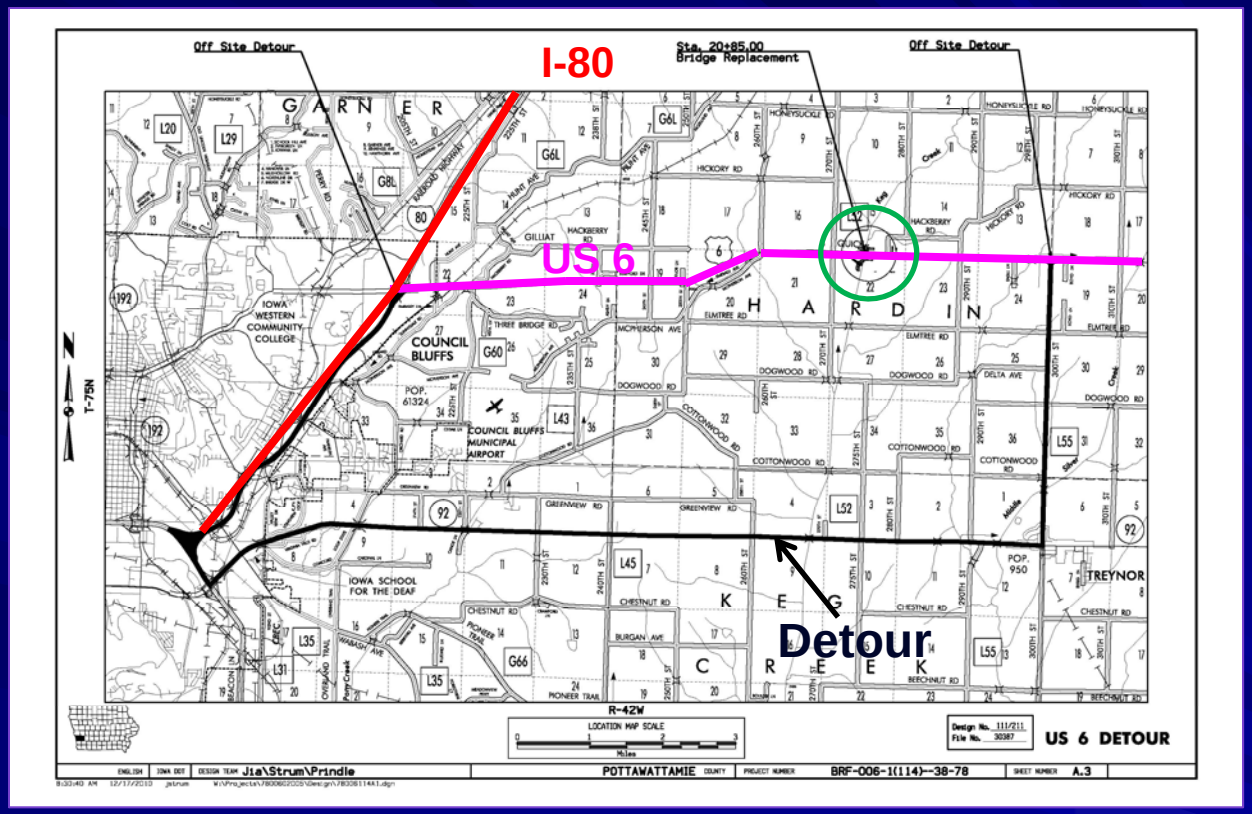
- TRB / SHRP2 / HNTB – R04 Research Team needed to demonstrate an ABC modular design concept for a typical multi-span stream crossing – a common rural bridge replacement.
- Late 2009, HNTB and DOT agreed upon a demonstration project in Iowa by end of year 2011.
- Keg Creek is 1st generation bridge in Iowa where construction is entirely modular and ABC.
- Successful project may pave the way for developing national ABC standards through SHRP2 R04 – “ABC tool-kit”.

PROJECT LOCATION



- US Highway 6 Bridge over Keg Creek
- 6 miles east of Council Bluffs, IA

PROJECT LOCATION



- Rural Location - 3900 AADT with 9% Trucks (2011)
- 22 Mile Detour (13 miles out-of-distance travel)

EXISTING BRIDGE

180’ x 28’-0 Continuous concrete girder bridge

- Built in 1953
- 3 spans

  53’-6”,73’,53-’6”
- Moderate sized, typical rural crossing
- Small, meandering stream
- Narrow 28’ bridge width on primary road system
- Sufficiency rating = 33

Why Keg Creek?

- Typical rural, moderate size stream crossing in Iowa. Indicative of many bridges throughout the mid-west and country. SHRP2 looking to standardize ABC design plans for rapid renewal.
- The 13 miles out-of-distance travel inconvenient for traveling public and escalates user cost over 4 to 6 months period versus 2 week ABC period.

ABC Innovations

- Precast modular deck system
  - Precast Module = 8.5” HPC slab casted on 2 steel I-beams (RSB W30x99)
- Barriers casted on modules before erection
- Precast pier columns & bent caps
- Precast abutment footings & wings
- Precast approach pavement slabs

ABC Innovations

- Flexibility of Precasting: project specifications allowed contractor self-perform precasting or use of precast plant.
- UHPC joints: Ultra-High Performance Concrete. First bridge in US with full, moment-resisting UHPC joint at the piers.
- Grouted rebar couplers: for column connections to pier cap and drilled shafts for reinforcing bar continuity.
- Drilled shafts: non-closure construction outside of existing bridge footprint
- SCC high early strength mix: used to improve consolidation and increase the speed of construction.

Project Data

- Design: HNTB *(M. LaVoilette, B. Sivakumar, and K. Price)*
- Owner: Iowa DOT (*D. Evans – Design Review, B. Flippin & G. Feazell)*
- Testing: Iowa State University *(M. Rouse, B. Phares, D. Hartwell, D. Wood, and T. Wipf)*
- Contractor: Godbersen-Smith $2,658,823 *(7 bidders from $2.66M to $3.99M)*
- 204’-6 x 44’ Steel Modular Bridge
- Contract price for bridge is about $2,000,000.
- Unit cost: $231 per sq. ft. (bid price)

  vs. $124 per sq. ft. (estimated for conventional CIP)

Project Data

- Contract period: Fall 2011 Construction
  - Phase 1: Drilled shaft installation (9 working days)
  - Phase 2: ABC Period (14 calendar days of road closure with Traffic Detour)
  - Phase 3: Revetment, grading, and flumes (20 working days)
- Incentive/Disincentive on 14 days ABC: $22,000 / day
- ABC approximate start date: 9/19/11 *(actual 10/17/11)*
- SHRP2 funds: $250,000 HFL funds: $600,000 or 20%
- UHPC Cost: $5000 / cu. yd. x 33 cu. yd = $165,000

PROJECT DOCUMENTS DELIVERED

- Integrated Project Plan Set
  - Bridge sheets in-house: 2 - TS&L sheets including channel grading, revetment, and rock flumes.
  - Soils sheets: 4 sheets w/ rock corings
  - Consultant sheets: ~40 structural sheets
  - Road sheets in-house: ~30 approach roadway sheets
  - Concrete flume plans ~ 8 sheets
- Special Provisions
  - SP-090109, Precast Concrete Approach Slab Elements
  - SP-090110, Precast Concrete Substructure Elements
  - SP-090111, Prefabricated Superstructure Modules
  - SP-090112a, Ultra-High Performance Concrete

PROJECT SITE - RURAL

New Bridge Geometry

- 204’-6 x 44’ Steel Modular Bridge
- 3 span: 67’-3, 70’-0, 67’-3
- 0 degree skew
- Relatively flat profile grade line on straight road (crest curve)
- Simple geometry allows for replication of units
  - Same girder length and shear studs used for all spans and all units
  - Un-cambered girders (choice of contractor)
- 2% deck slope from centerline with no parabolic crown


USGS Log Cabin
Council Bluffs, Iowa

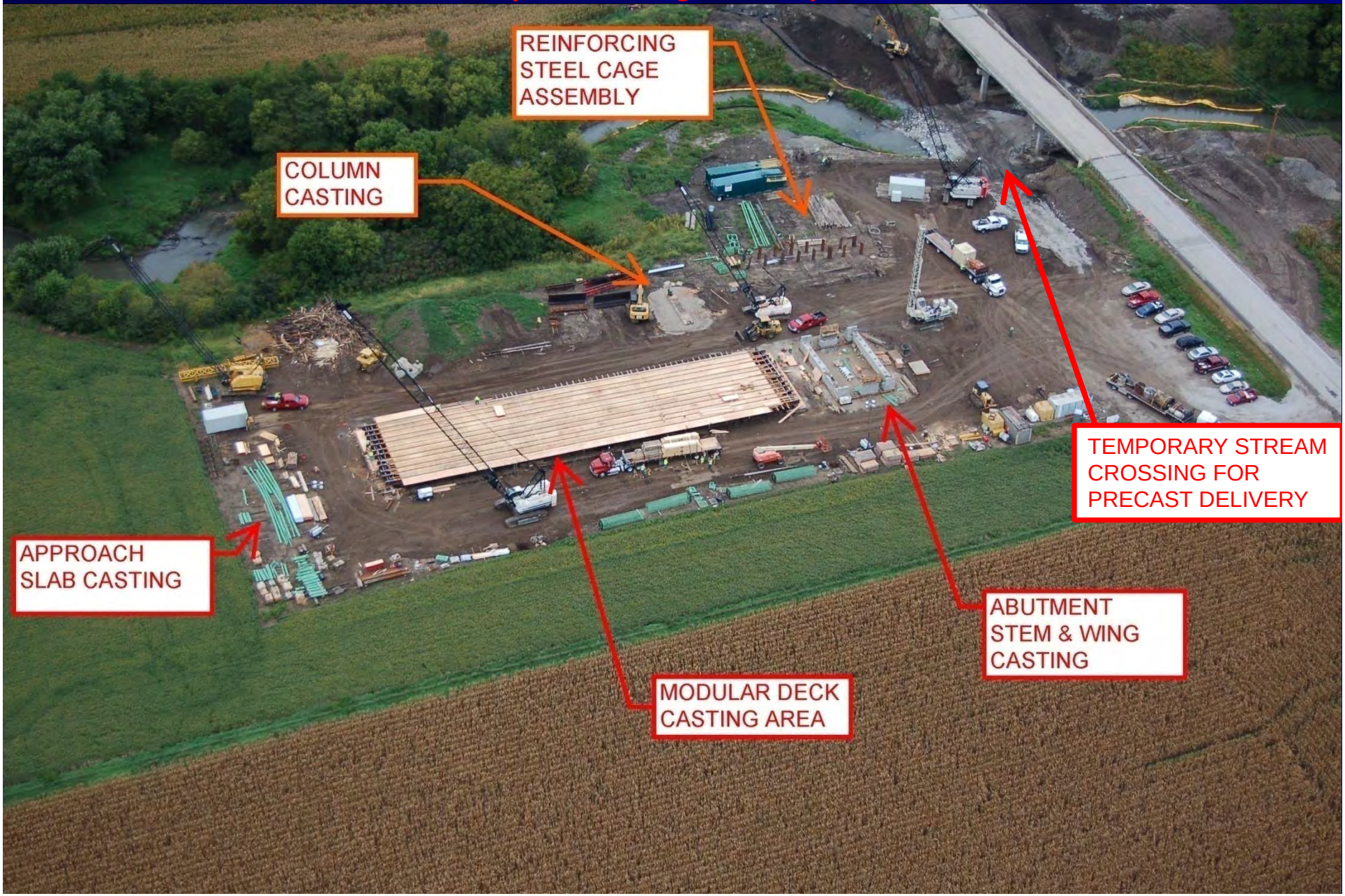
FABRICATION

- Precasting: precast plant fabrication per Iowa DOT Standard Specifications and Materials IM 570.
- Special Provisions and "Alternate Site Casting" plan notes provided necessary specifications for prefabrication of units.
- Godberson-Smith elected to self perform casting on site.
- Site casting was a large cost-savings for project.
- HPC with 5,000 psi concrete.
- Mild epoxy coated steel reinforcing (no prestressing).

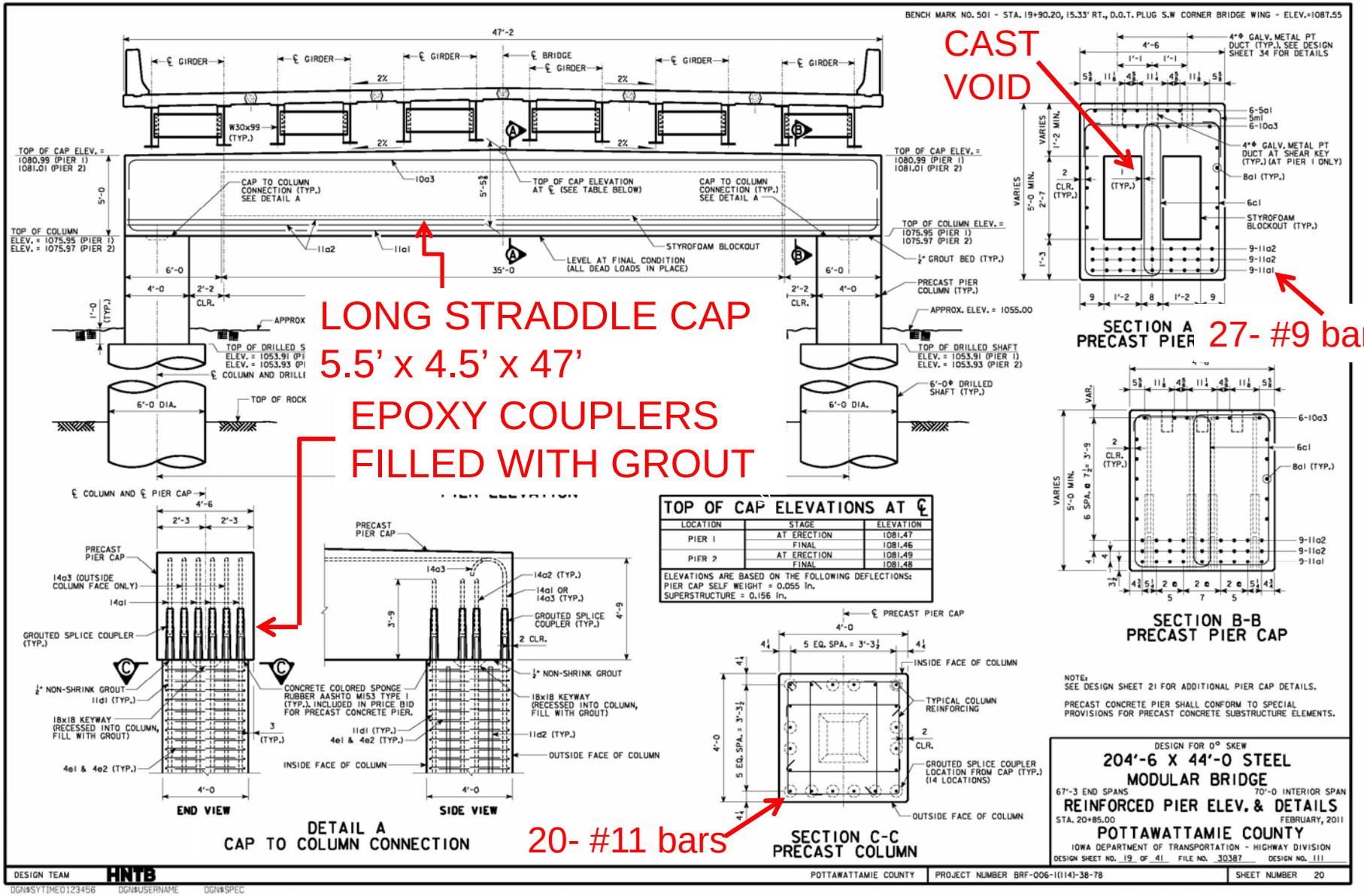


SELF PERFORM PREFABRICATION

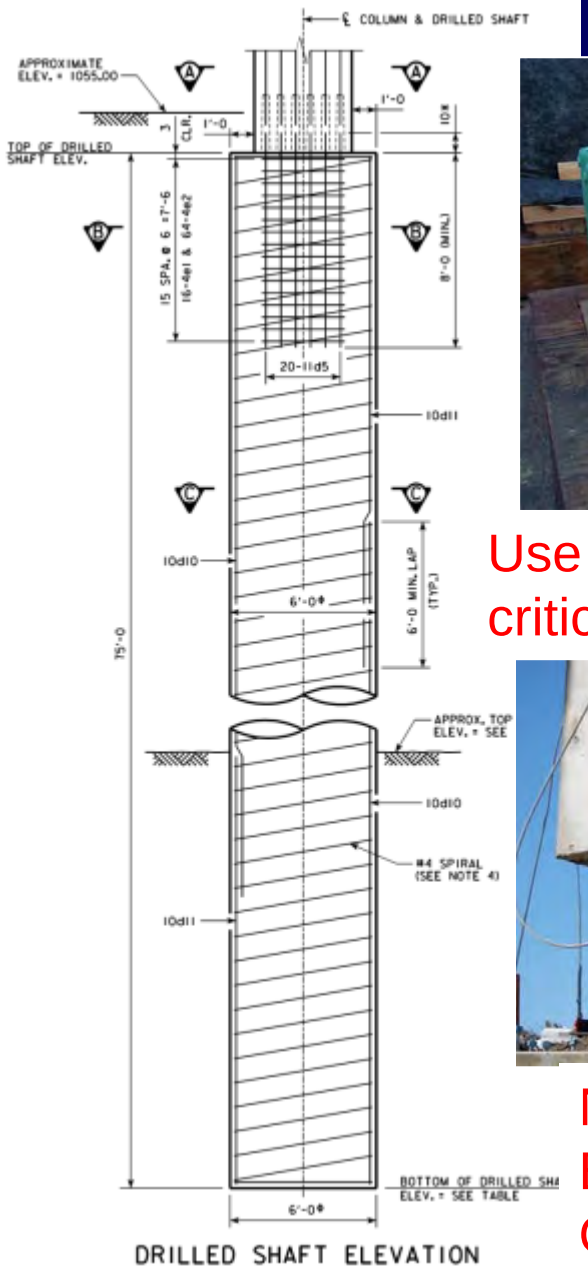
(Iowa Bridge Farm)



PIER DETAILS

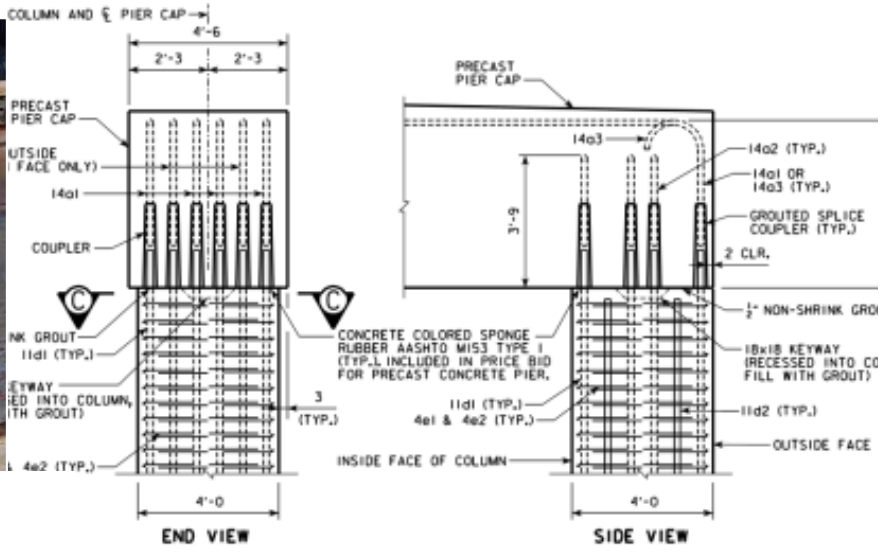


Pier Connection Details

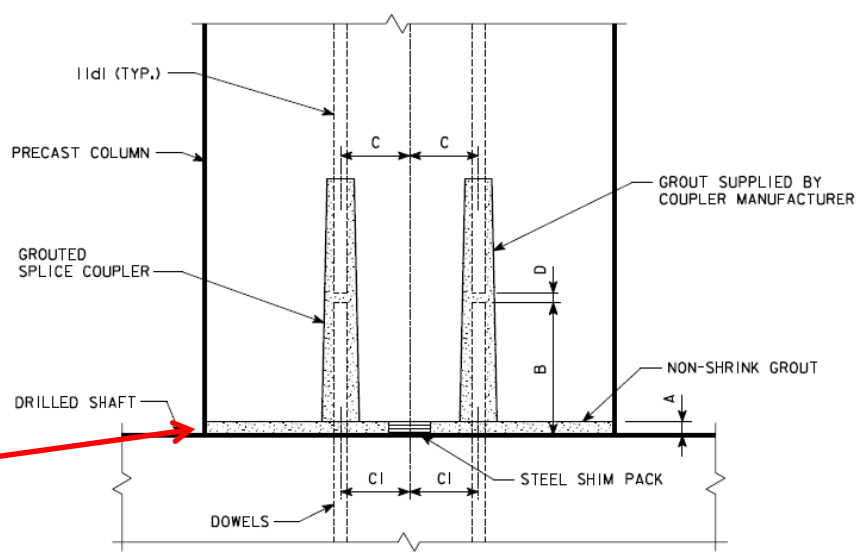


Use of rigid template is critical to fit up.

NON-SHRINK BEDDING GROUT

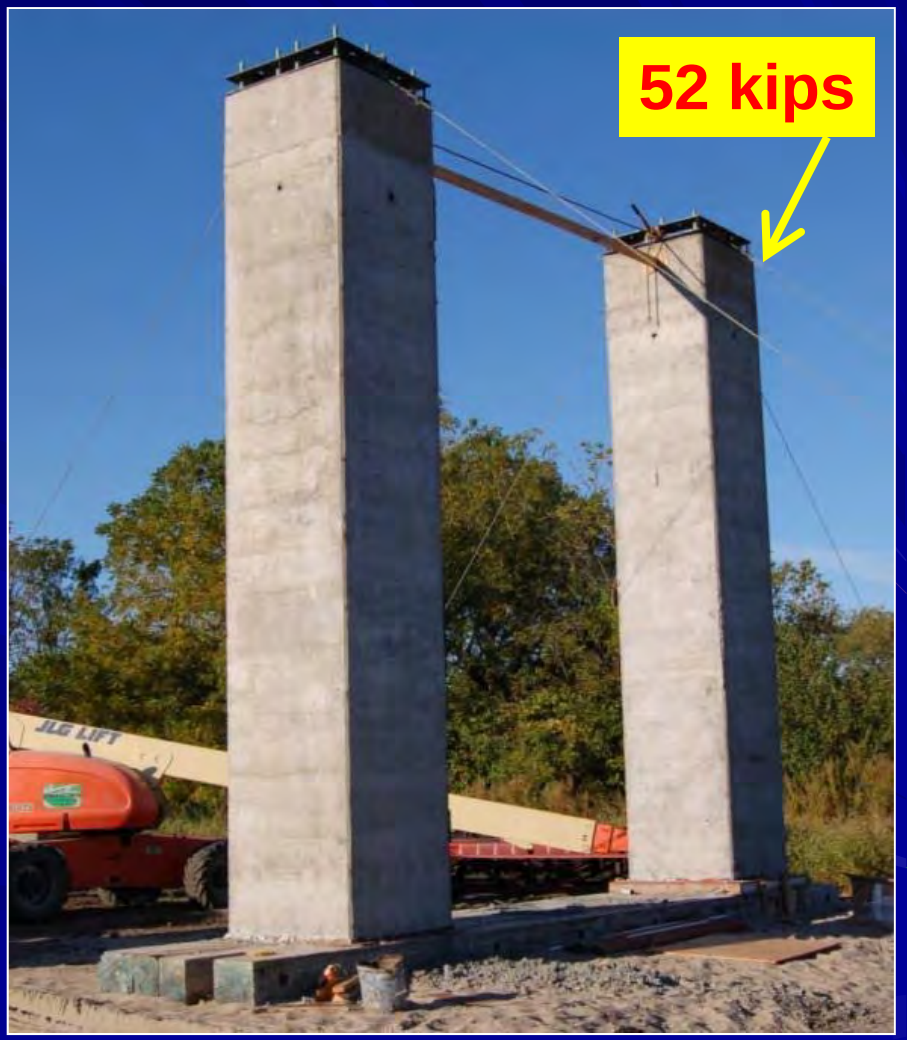


DETAIL A
CAP TO COLUMN CONNECTION



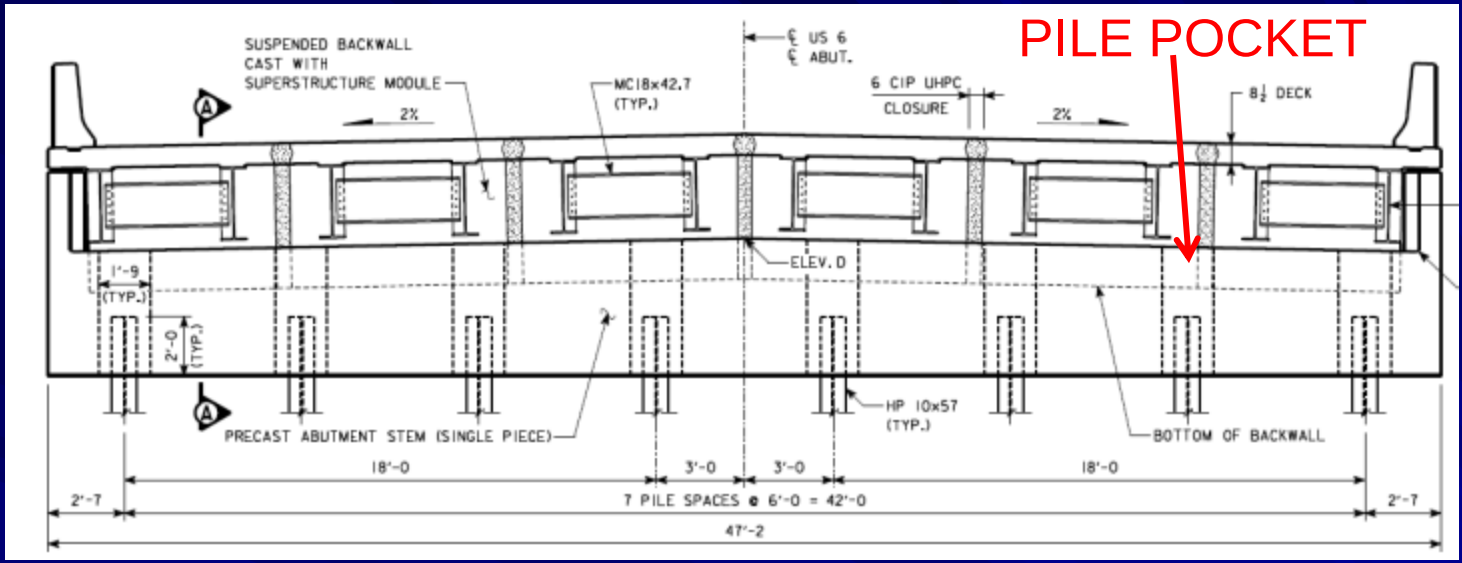
GROUTED SPLICE COUPLER DETAILS

Precast Substructure Components Casting



4 ft wide square columns casted vertical

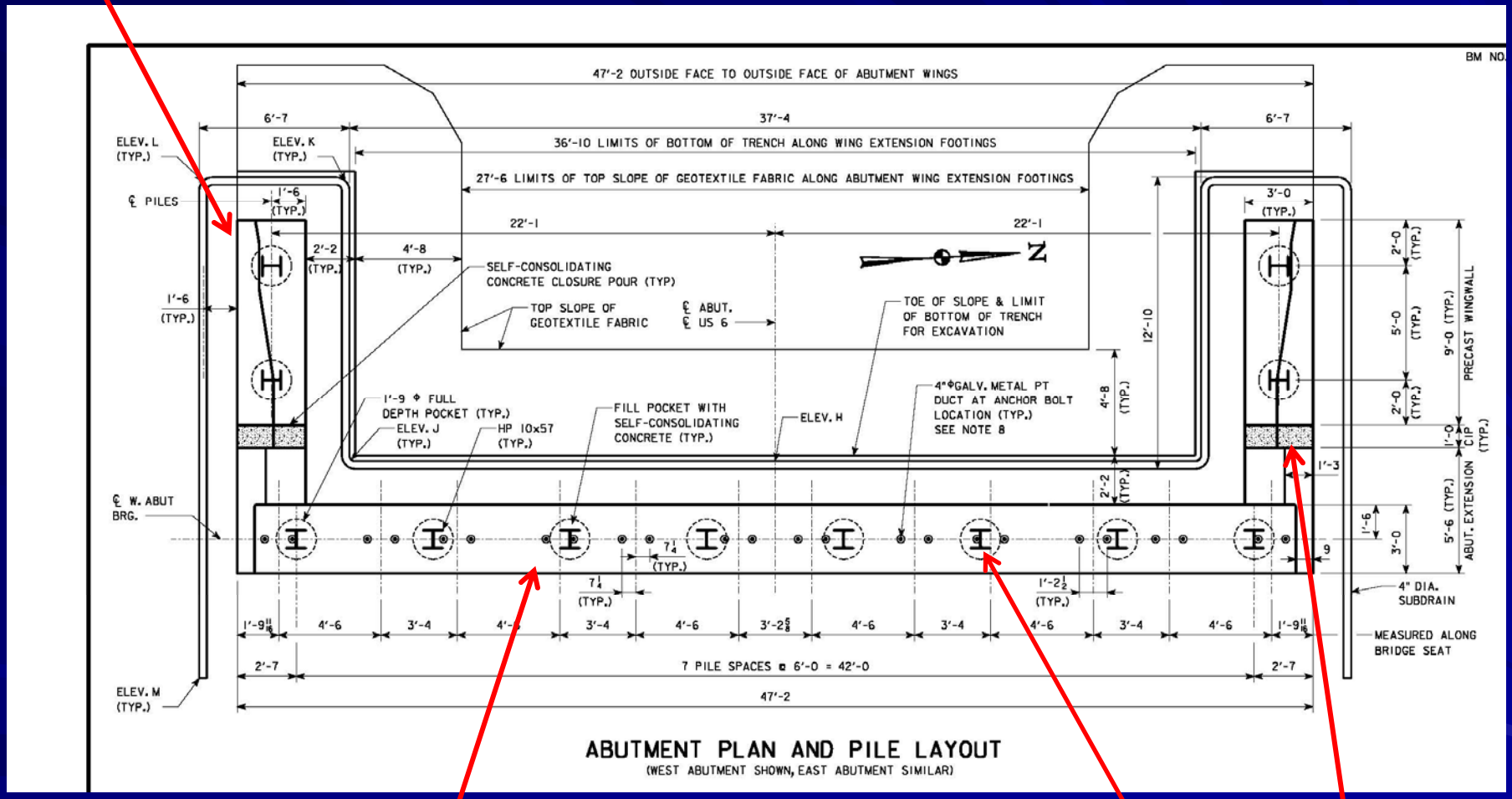
Abutment Details



- Cont. reinforced concrete abutment footing
- Corrugated metal pipe to form pile pockets
- Single row of H-piles driven
- SCC to fill pile pockets; high early strength
- Temporary support of footing until SCC reaches 3000 psi

ABUTMENTS DETAILS

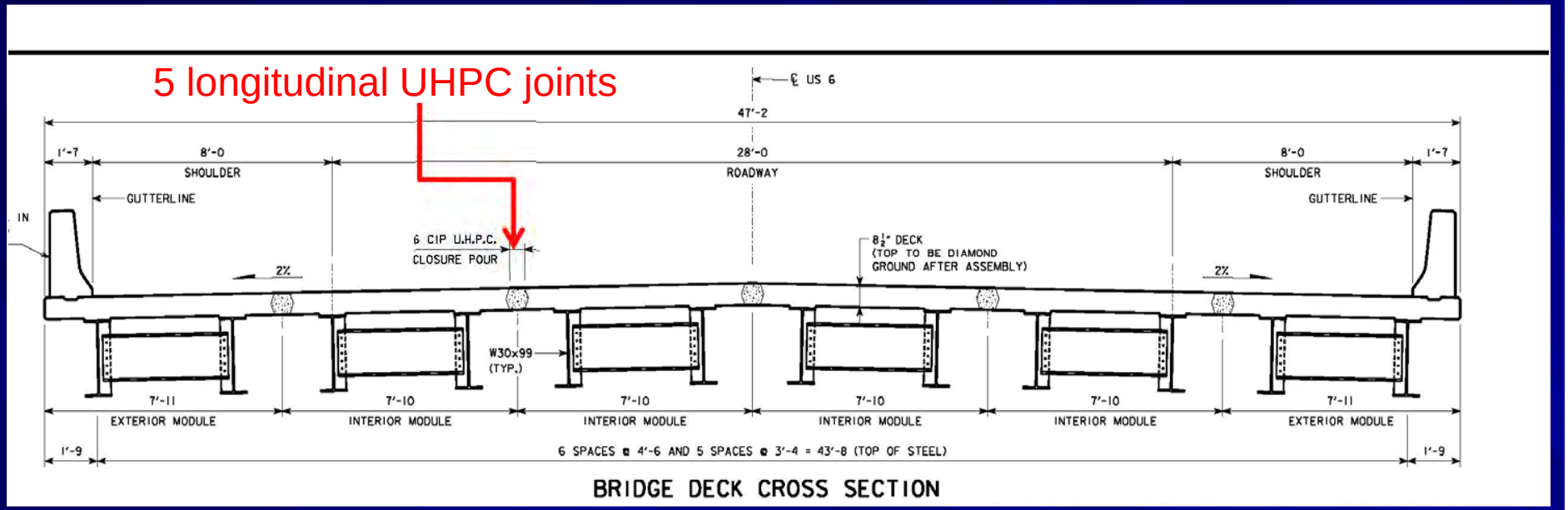
WING UNIT



ABUT STEM

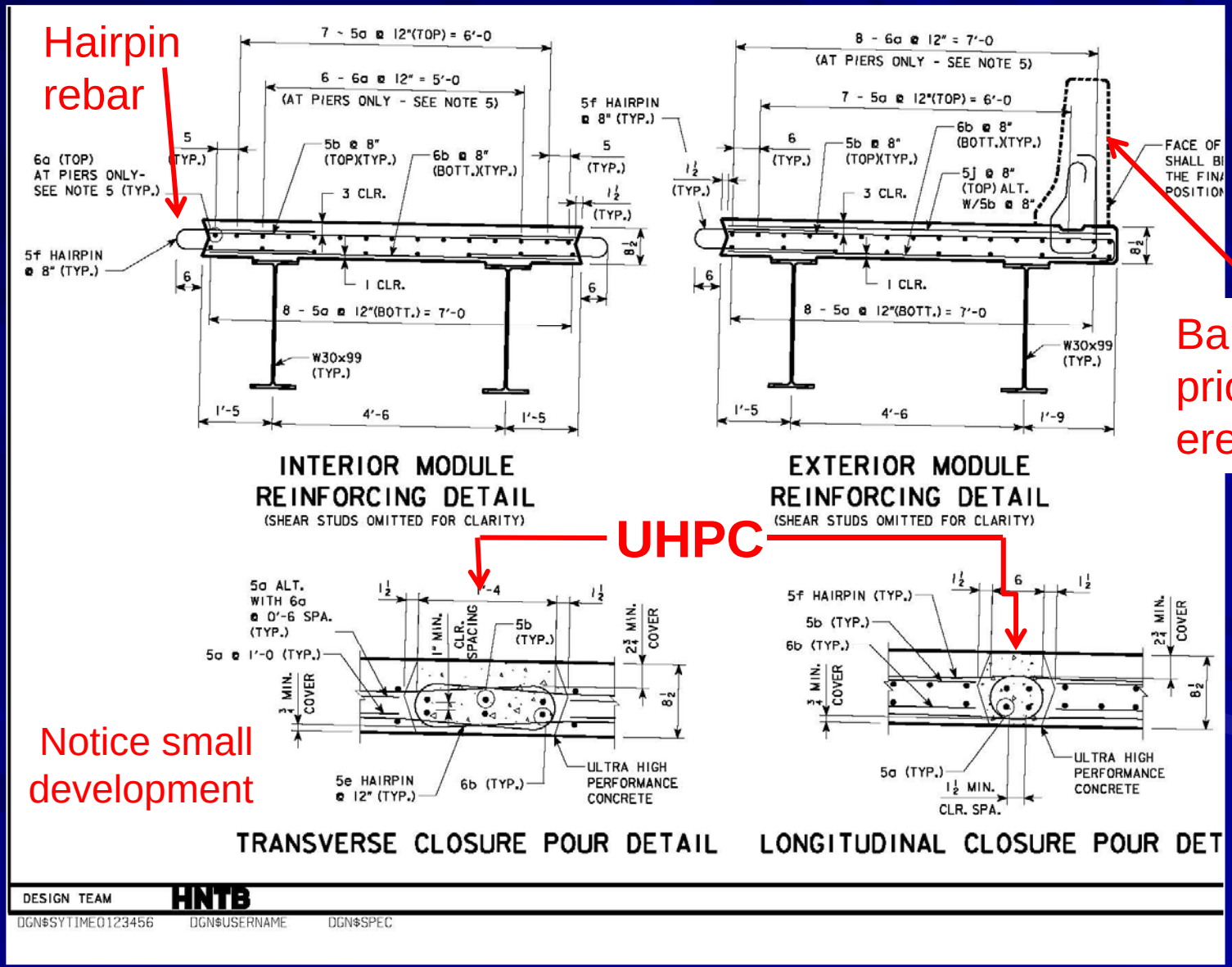
SCC POUR

DECK MODULE DETAILS



- 6 units in deck cross section (6 units x 3 spans = 18 units).
- 8.5” slab casted on 2 beam lines (0.5” grinding allowance).
- Units are joined by transverse and longitudinal UHPC closure pours and epoxy coated dowels (hairpins).

DECK MODULE DETAILS



Prefabrication of Steel Modules


Girders assembled on bents with diaphragms and end plates bolted


Temporary bents for Modular Deck Casting

- Steel was fabricated in the shop and set on temporary bents.
- Contractor chose to fabricate modules in their exact relative location and cast the deck with traditional paver.
- This requires the contractor to provide formed voids in the deck for the UHPC joints and allows contractor to separate the modules.

Prefabrication of Steel Modules

- All formwork for the deck was supported from the longitudinal girders similar to conventional construction.
- The deck concrete was cast on-site.

Continuity connection at the pier

- Simple for DL ; Continuous for LL
- UHPC joint reinforced to carry the full LL tension
- First use on the Keg Creek Bridge, Iowa

Precast Approach Slabs

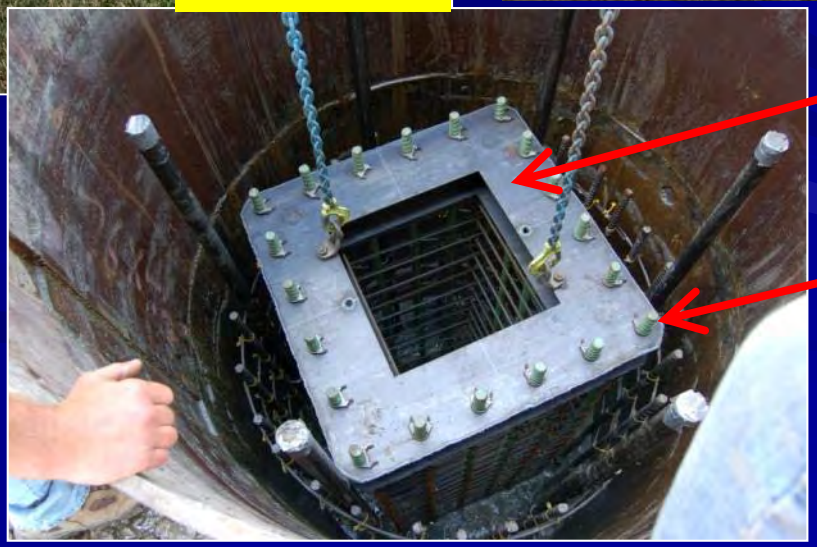
- Traditional CIP – 4 units each end of bridge
- Double Reinforced Mat
- Sleeper Slabs
- Form slab edge around barrier end

Drilled Shaft Construction

(Phase 1)

- Location of drilled shaft is critical because of limited tolerance of pier placement
- Typ. shaft tolerance is 2” to 3” per CIP Std Specs….. FOR THIS CASE 1” TOLERANCE.
- Rigid template for connecting shaft dowels to the column couplers is a MUST!

Drilled Shaft location allows for work under traffic

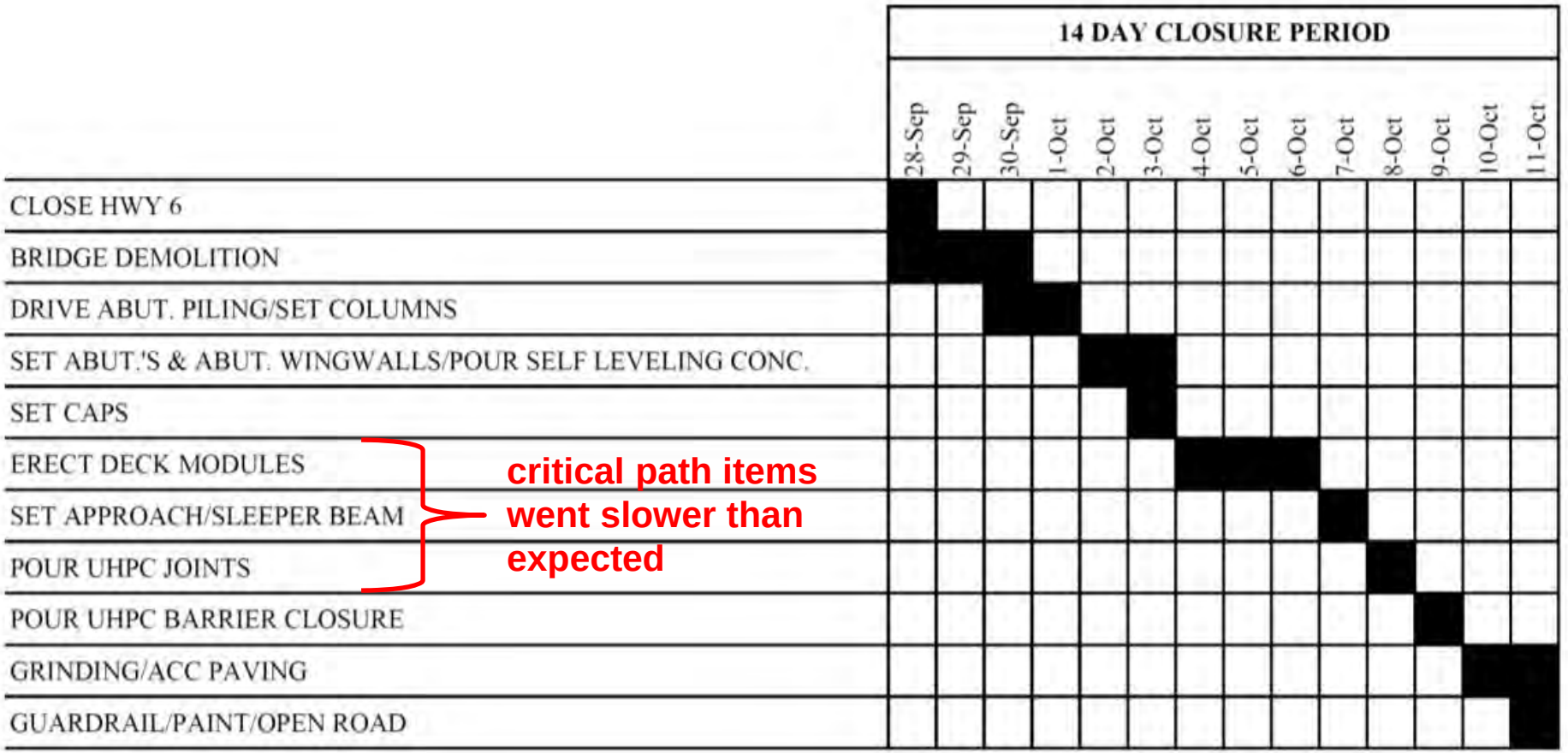


Rigid template

Dowels for Splice coupler connection

14 Day ABC Timeline – Phase 2

(as proposed by the Contractor)



- *Contractor targeted day shift only of 6 am to 8 pm*
- *Actual 16 day ABC period: Oct. 17 – Nov. 1*

(OPEN TO TRAFFIC NOV. 2)

Day 1, Oct. 17 - Demolition

- Demolition completed within a single day
- Two hydraulic breakers mounted on excavators
- Crane with wrecking ball
- Protection of new drilled shafts
- Protection of new pier caps

Day 2, Oct. 18 – Drive Pile and Removals

- Continue to remove debris
- Excavate and shape abutment footing area
- Start to drive pile! 24-7
- (12) 80’- HP10 x 57 piling each abutment
- One pile splice weld per pile
- Remove drilled shaft temp. casing

Day 3, Oct. 19 – Prep Time

- Debris cleared
- Continue driving pile and making pile splices
- Cut pile ends
- Equipment preparation for precast moves
- Move Pier Caps

Day 4 – Oct. 20 Column Assembly

- Cutoff drilled shaft dowels and place shim plates

- Add non-shrink bedding grout
- Bedding grout should be slightly overfilled and crowned
- Provide perimeter barrier around grout bed

Day 4 , Oct. 20 - Column Assembly

- 52 kips precast
- 1- 110 ton crawler crane

- Columns need to be match marked for placement

Precast Column Erection

Day 4

- Mid-afternoon contractor done with column erection ~ 1.5 hour / column
- Still need to grout rebar couplers at base

Bedding and Coupler Grouting

- Sponge rubber bedding grout dam for retention
- Grouting procedure is critical! Workers need to be trained and supervised by manufacturer.
- Very critical to get entire chamber of couplers filled to develop bond to steel reinforcing.

Day 4

Grout specimens collected for strength testing before adding load

Temporary Abutment Supports

Day 4

- Piling finished about 48 hours after day 2.
- Contractor casted high early strength bearing pads after pile driving

Day 5 Oct, 21 Abutment / Wing Erection

- 110 ton crane each wing
- 200 ton crane for abutment precast

•3 crane erection sequence went well

SCC – Abutment Pile Pockets

Day 6

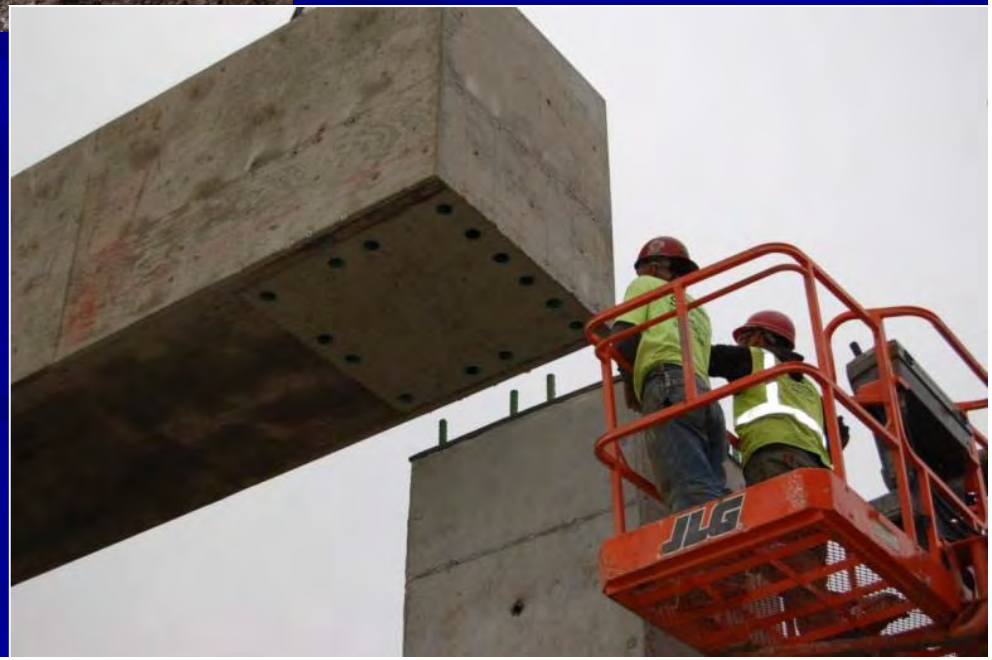
Cast SCC ASAP for cure time

Cylinder breaks on SCC before modules

Day 6 – Oct. 22

- Grout breaks - OK
- 84 Ton
- (2) – HC110s Largest Iowa precast lift.
- Used typical embedded P/S strand

Cap Beam Erection & Assembly



Cap Beam Erection & Assembly

Day 6

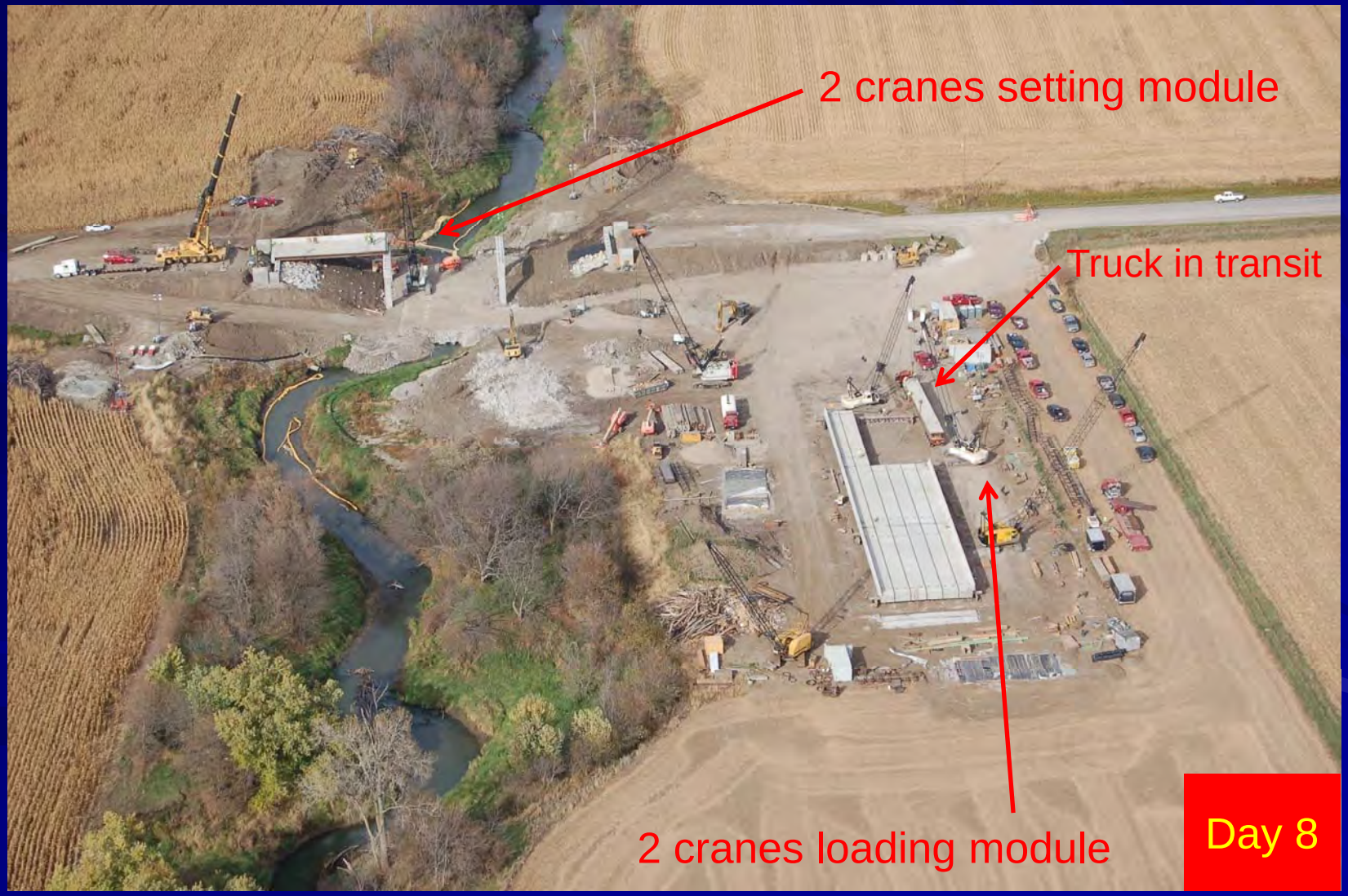
This was certainly easy! This could be utilized for 4 span or larger bridge. Access in the stream channel was key!

Superstructure Module erection

Day 8 – Oct. 24

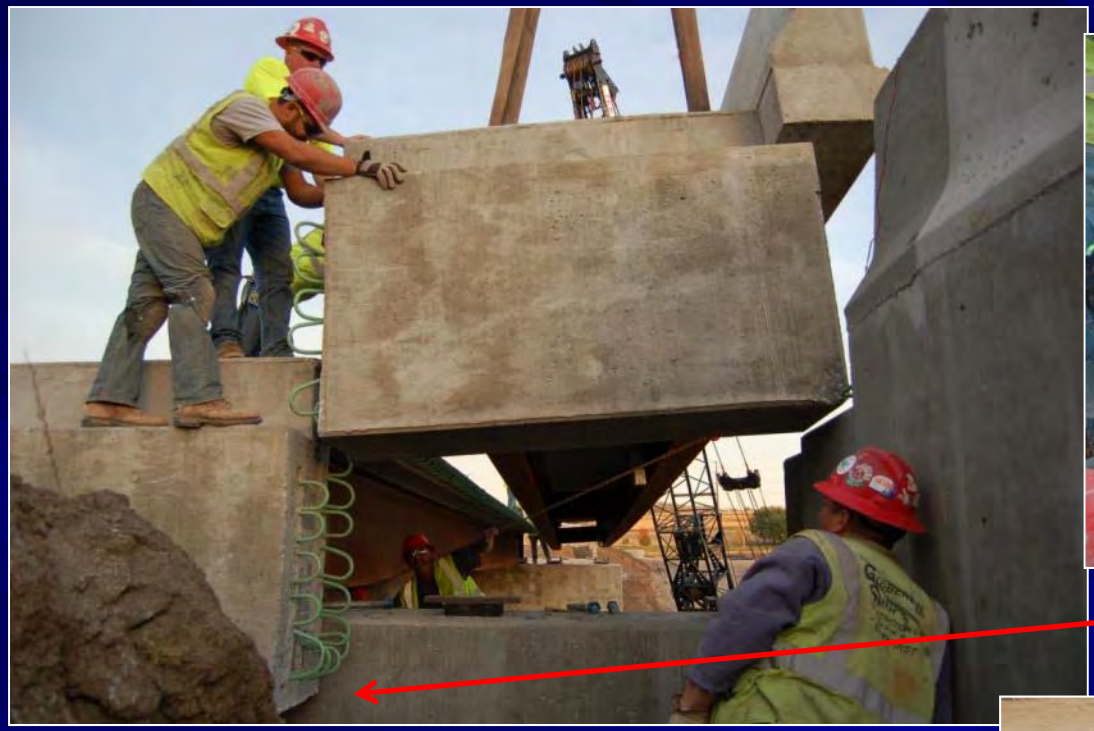
- 1 week into closure period. SCC & grout cure was achieved on day 7.
- 2 crane pick. 110 ton & 200 ton
- Exterior modules had to be carefully rigged for a balanced lift.
- Picking points at girder lines.
- Systematic operation of loading, transporting, and erecting.
- Targeted 2-3 days for erecting

Superstructure Module Erection



Module Assembly -

Days 8, 9, & 10



Hairpin rebar is problematic

- Contractor had difficulty with fitting the modulus because of the “hairpin” joint bars.
- Module deck reinforcing should utilize straight bar ends and take advantage of UHPC bonding characteristics.
- Joint design should minimize reinforcing to avoid fit-up problems.

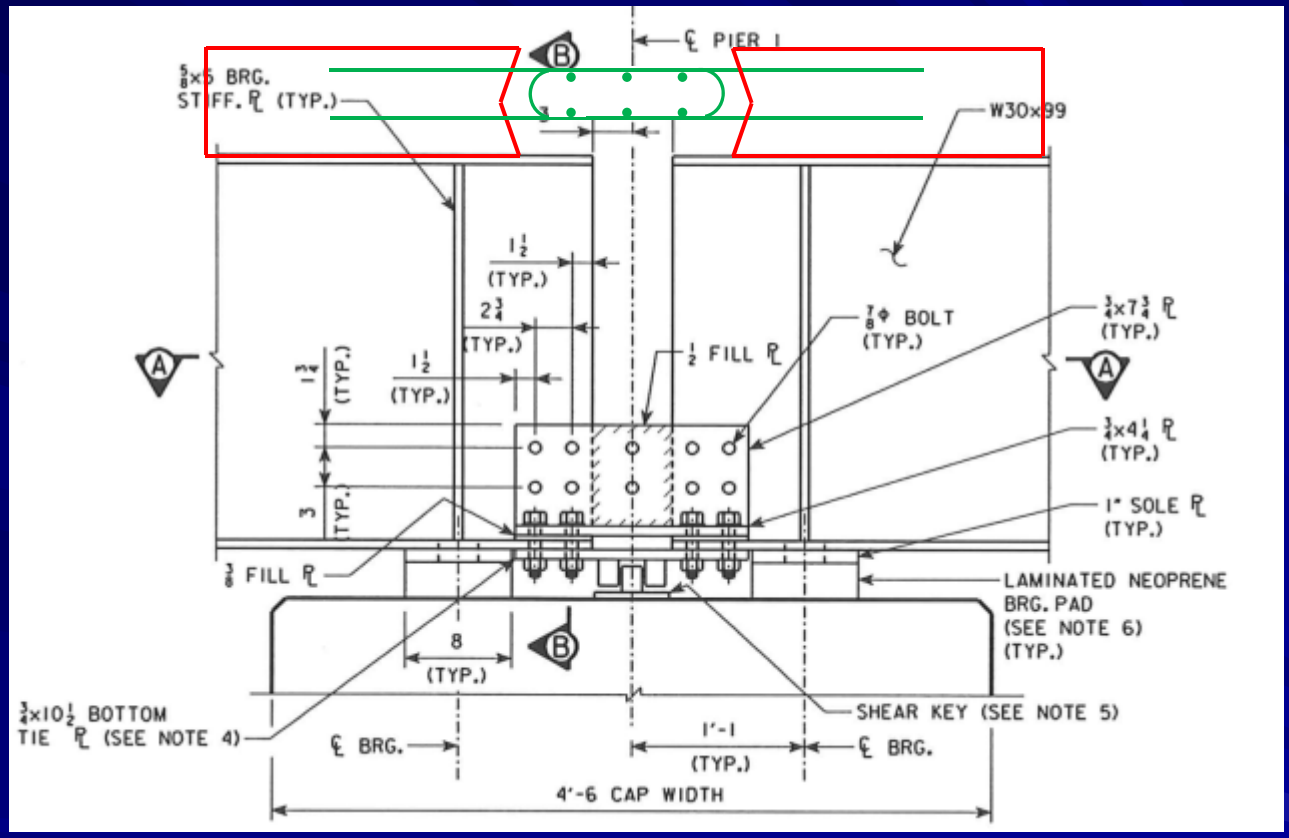
Forming, Bolting, field welded bearings, & joint reinforcing

Days 10, 11, & 12

Lots of joint form = $$ labor

- Bolting modules over pier requires precision placement
- Is this type of connection suitable for ABC?
- Bottom flange is in compression.

Connection over pier



- Requires field fillet weld at the sole plates which is slow.
- Requires precision placement of the modules for bolting.

JOINT REINFORCING

Joint rebar = $$ labor

Need to minimize rebar congestion

Days 10, 11, & 12

Epoxy coating can be damaged

Flooded Backfill System – Days 10 & 11

Precast Approach (east end) - Day 11

- Subgrade surface needs to be level and well compacted to hit cross slope and elevations.
- Placement of sleeper slab and 4 precast panels
- Contractor was not particularly fond of precast approaches and would prefer accelerated cure mix CIP.

WELCOME TO INTRO TO UHPC!

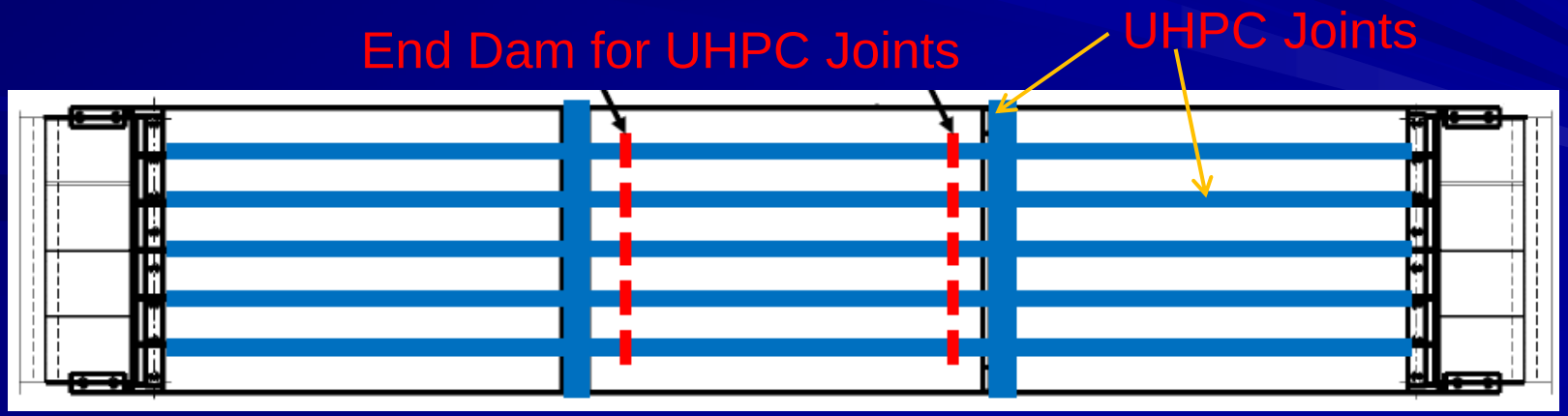
- Highly flowable, but slow (good and bad)
- Slow initial hydration rate (first 12 hours)
- Low permeability. High durability
- Lower shrinkage than concrete
- Advanced bonding mechanism to rebar
- High compression strength (15 ksi to 30 ksi)
- Contains 290 ksi steel fibers; capable of resisting tension.
- Self-consolidating
- Limited workability, only gravity
- Environmentally sensitive (wind, sun, and temperature).

UHPC JOINT POUR – DAY 12, Oct. 28

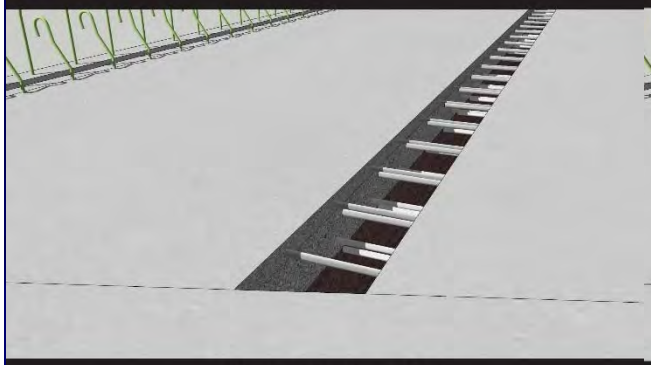
- Proper UHPC joint placement is vital to the long term serviceability of a modular deck bridge. Do not underestimate the criticality!!
- A textured edge of the precast deck is required. ICRI surface roughness = 6 to 10 (range)
  1. Exposed Aggregate Finish: Application of a retarder on the form and removal of the form after set. Pressure wash to expose aggregate by removing cement paste.
  2. Textured form liner + Sandblast Finish: use of textured liner with a sandblast to open up some microscopic pores. This will require stainless steel bars protruding from the joints.
- When you cast UHPC, a saturated surface dry edge of precast is imperative. (moist or damp)

UHPC JOINT POUR – DAY 12, OCT. 28

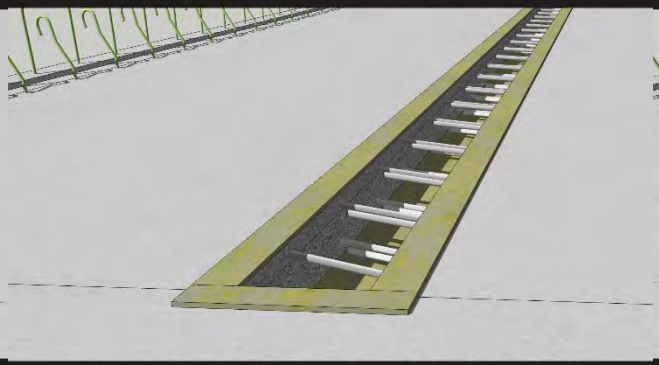
- Joint forms needs to be sealed tight!!
- Build joint dams to limit size of pour (5 -10 C.Y.). UHPC is hard to manage in large pours. Mixed in small batches.
- Pour the concrete on the uphill side at staged locations.
- Provide joint ledge forms and overfill the joints slightly.
- Install cap forms as you go to isolate UHPC from air.
- End with a chimney form



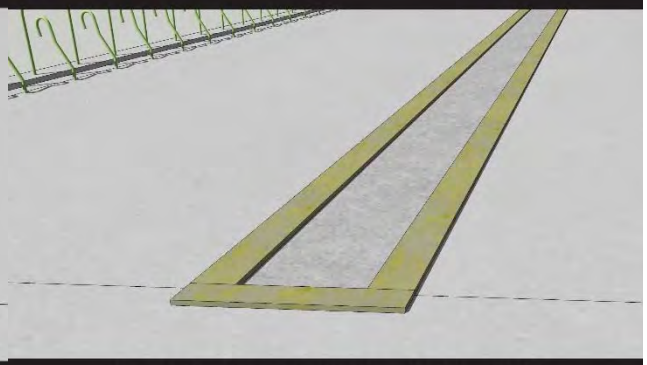
UHPC JOINT SEQUENCE



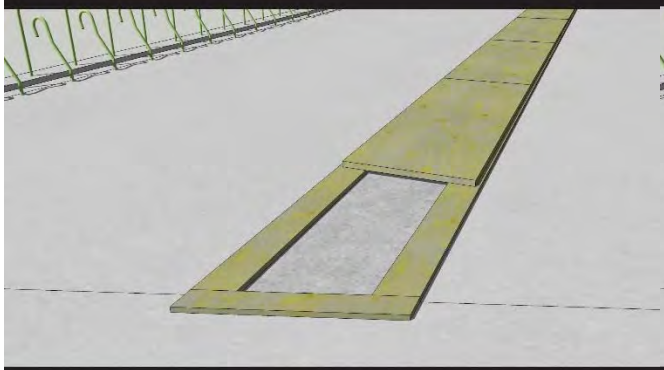
LONGITUDINAL JOINT



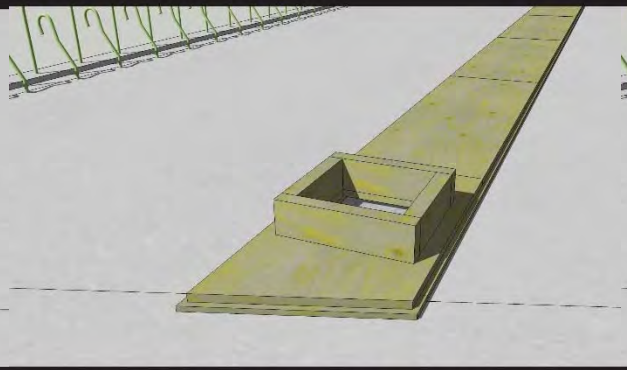
LONGITUDINAL JOINT BOTTOM AND SIDE FORMS



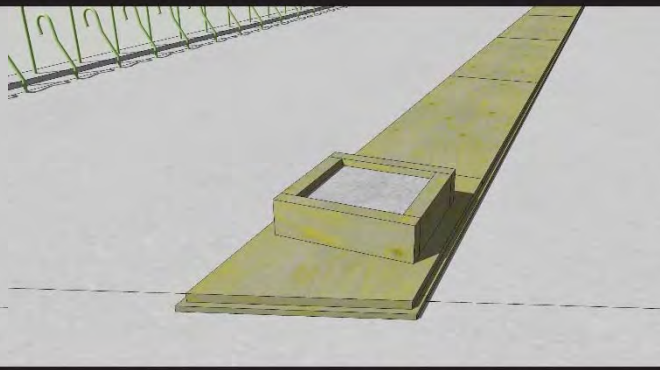
U.H.P.C. FILLED LONGITUDINAL JOINT



U.H.P.C. LONGITUDINAL JOINT WITH TOP FORMS



FORMED CHIMNEY AT HIGH END LONGIT. JOINT



U.H.P.C. SURCHARGE AT CHIMNEY

UHPC PREPARATION

- UHPC producers typical will provide mixing equipment and all admixtures.
- UHPC producer will typical send a experience technician to direct and oversee.
- UHPC cement will be in large bags heavy enough to warrant a crane.
- UHPC mixing is complex and precision is needed.
- Large UHPC pours require a large crew for mixing and casting

UHPC MIXING – DAY 12

DUCTAL
BAG MIX

- UHPC MIXING REQUIREMENTS ARE SPECIFIC AND CONTROLLED BY SPECIAL PROVISIONS.

STEEL
FIBERS

PRECISION
INGREDIENTS

UHPC Placement – Day 12

Cap forms

- Transport UHPC with buggy.
- UHPC is very flowable.
- No voids.
- Self Consolidating

Flowability

UHPC VIDEO SLIDE

Day 13 – Oct. 29, West Approach slab, Barrier Closure Joint, UHPC Cure

- Waiting for UHPC 2 day cure time to break cylinders.
- Grinding after 10 ksi is verified.
- Cast barrier closure joints and module deck pick point voids
- Heat blankets to accelerate cure can be used.
- Thermally control cure if cold.
- UHPC mixes today can cure faster (24 hours).

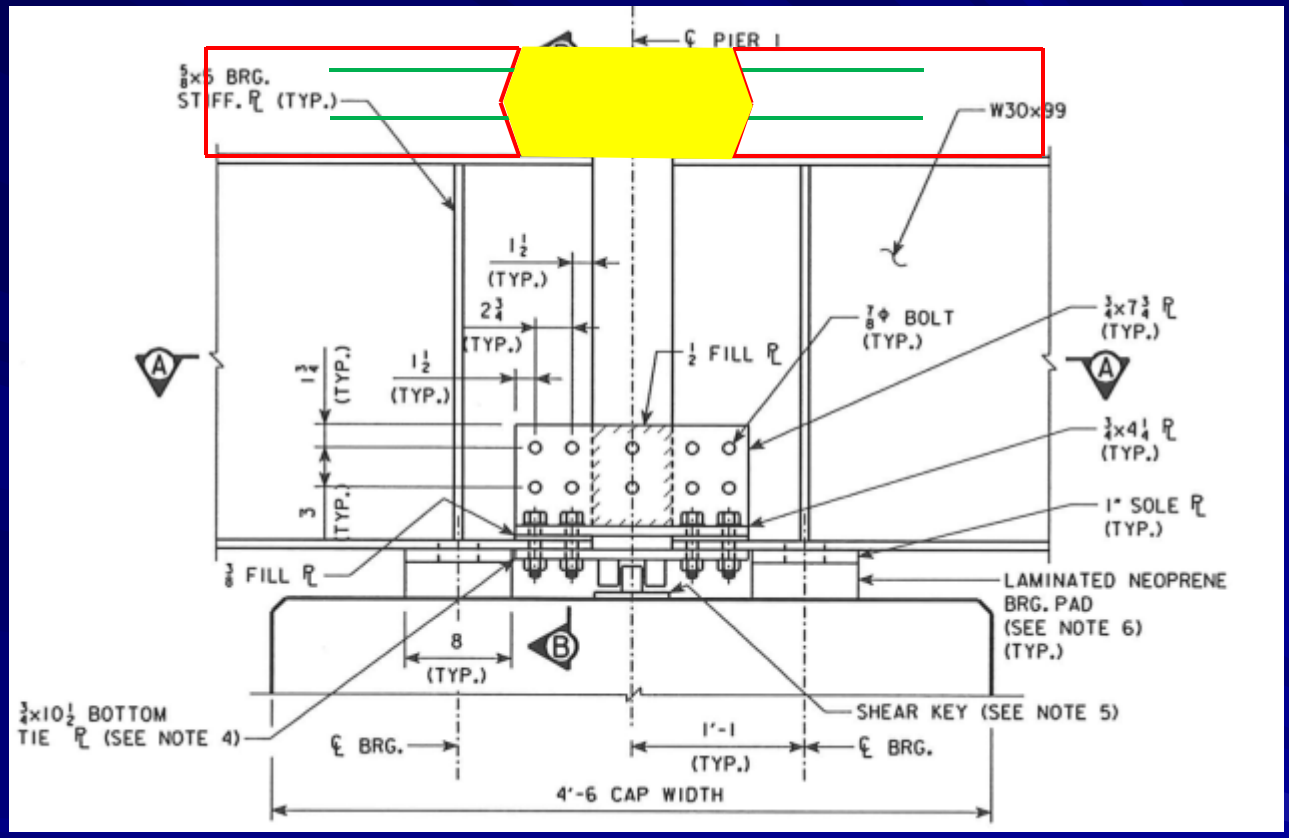
Day 14 – Oct. 30

- Targeted last ABC work day. Unable to meet deadline.
- Break cylinders for 2 day cure time. Cylinder tests avg. 14 ksi (> 10 ksi)
- Casting precast approach joints with UHPC.
- Begin approach roadway excavation/grading for HMA transition to existing pavement.

Day 15 – Oct. 31

- 1 day over ABC
- Finish fillet welds on bearings.
- Grind bridge to profile and eliminate surface irregularities.
- Pave shoulder and mainline with ACC wedge for transition to existing pavement.
- Post-tensioning of the retro-fit Dwydeg bars at the pier.

Transverse UHPC Joint at the Pier



- The transverse joint over the pier is a region of direct tensile strain in the slab because of negative moment continuity.
- Places potential weak zone in high tension location -- a crack in the interface of UHPC / Module Deck Concrete.

Post-Tensioning Retrofit

- As of 2011, no research for UHPC used in this condition.
- ISU Report: *Laboratory and Field Testing of an Accelerated Bridge Construction Demonstration Bridge: US Highway 6 Bridge over Keg Creek*
- ISU conducted a full scale test of the module to module connection with the UHPC in the joint.
- Indication the UHPC was debonded from edge of the precast.
- If the interface cracks, potential for joint leakage.
- Result of test, let Iowa DOT to add the retro-fit P/T rods.

Day 15 – POST-TENSION OVER PIERS

<u>48 Post-tension locations:</u>

- (4) rods per module stressed simultaneously to a min. 70 kips per rod

Day 16 – Nov. 1

- 2 days over ABC
- Finish bridge deck grinding/grooving.
- Guardrail placement
- Shoulder panel & ML PCC paving (w/ M-mix)
- Paint lines
- ISU installing Health Monitoring Hardware
- Load Test by ISU
- Bridge can be opened to traffic when UHPC has 15 ksi strength. Can occur in 3 to 4 days. (break cylinders)

Completed Bridge – Open Nov. 2

Conclusions

- ABC modular design concept was successfully demonstrated, but there were many challenges along the way.
- Post construction review identified problem areas as expected, and provided recommendations for design and constructability improvements.
- These improvements were implemented in a 2nd generation bridge (IA 92 over Little Silver Creek).
- As the result of this project (and other ABC projects), Iowa DOT gained a better understanding of risks and benefits associated with modular construction and has developed an ABC policy for the future.

Questions?

Iowa DOT ABC website

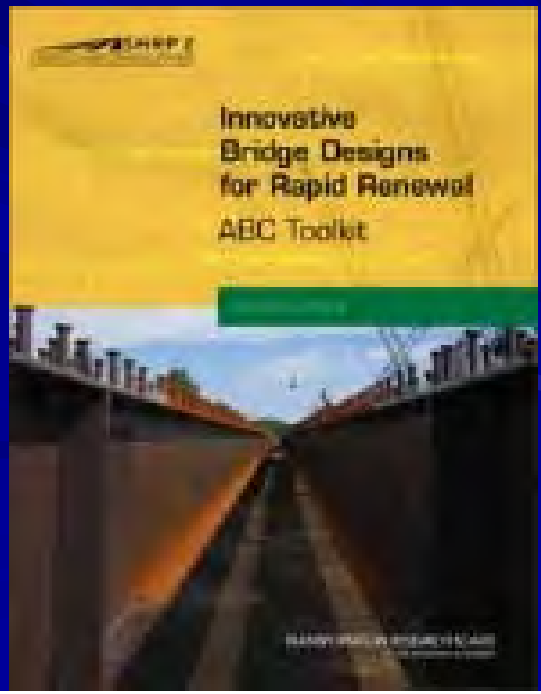
http://www.iowadot.gov/bridge/abc.htm

- US 6 over Keg Creek (modular ABC – 1st gen)
- IA 92 over Silver Creek (modular ABC – 2nd gen)
- IA 92 in Massena, IA (ABC lateral slide)

TRB – SHRP2 ABC toolkit

http://www.trb.org/Main/Blurbs/168046.aspx

- Innovative Bridge Designs for Rapid Renewal



Time lapse construction (next slide)

Time Lapse Construction

Following Slides for Discussion (not part of presentation)

LESSONS LEARNED

- ABC is a viable bridge construction alternative for Iowa.
- Margin of error is lower than cast-in-place.
- Need refinement of contract agreements, our own construction inspection program, and improvements to design/specifications for ABC.
- The premium cost for ABC is about double traditional methods (based on Keg Creek). Difficult to rationalize this without user costs for justification.

LESSONS LEARNED

Design / Construction

- Do not use narrow UHPC joint over the pier because of the potential for cracking at the interface of precast.
- Must have pre-pour meeting with UHPC supplier.
- Follow provisions and recommendation of supplier for casting UHPC joints. Bond at interface is critical!!
- Geometry/shape of the abutment diaphragm is problematic.
  - Difficult to seal inside face enabling UHPC to leak
  - Rectangular shape makes it difficult to backfill
  - Vertical joint rebar is congested causing erection difficulties.
- Joint steel congestion leads to increased labor costs and delays. Use straight bars in lieu of hairpin reinforcing.
- The beveled edge (or diamond shape) joint style is problematic at modular deck corners.

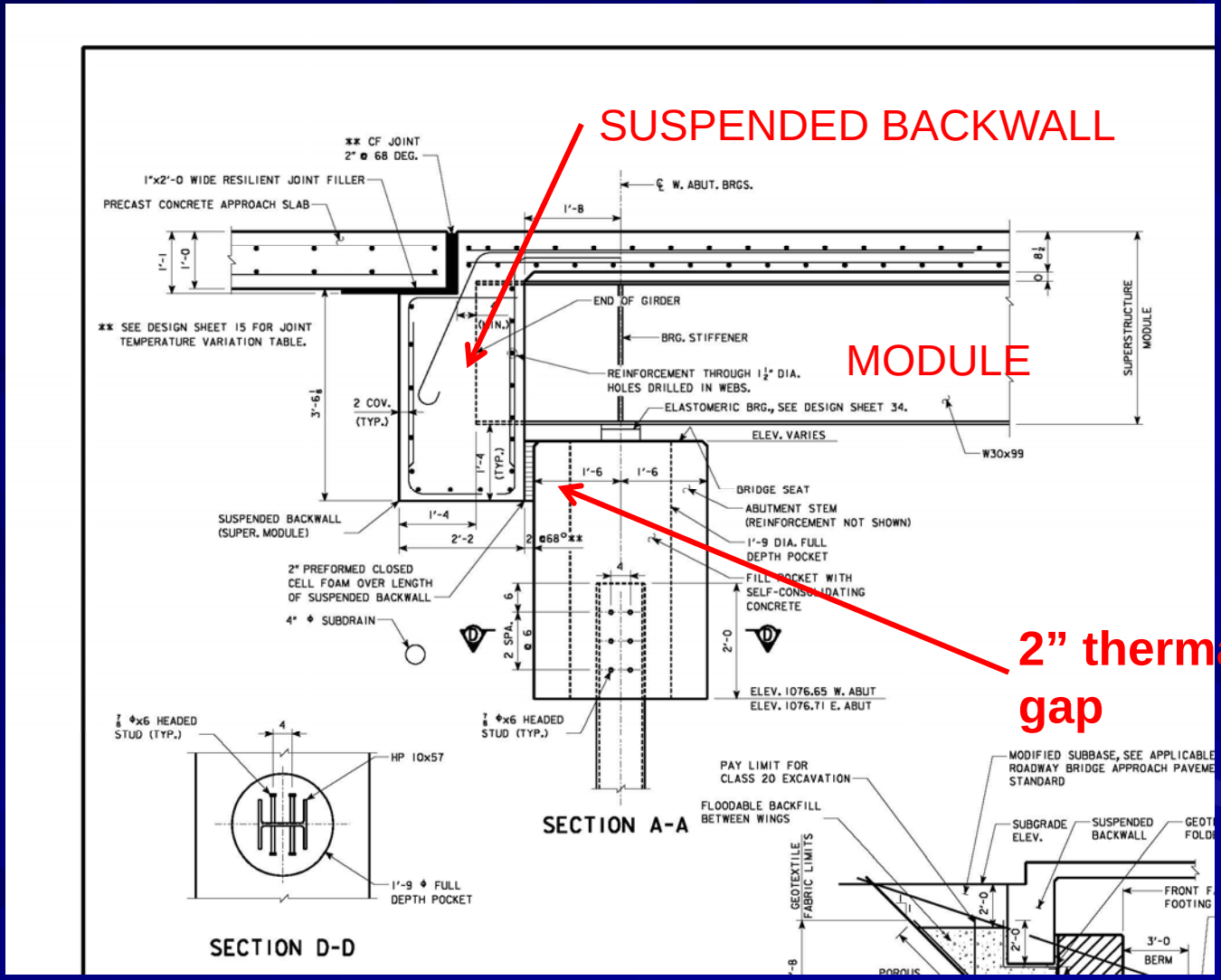
LESSONS LEARNED

- Contractual
  - The bid proposal should include a specific deadline for fabrication of all precast and modular deck components.
  - Consider adding a “grace period” if weather does not permit work (i.e. flooding). If weather delay is less than 5 days, the contractor isn’t compensated with more working days in Iowa.
  - Special provisions should contain the requirement to have 2 independent land surveying subcontractors. The 1st surveyor to layout and the 2nd as an independent check.
  - Perhaps the 14 days ABC should be extended anywhere from 16 to 21 days.

LESSONS LEARNED

- Inspection on-site
  - Increase number of inspectors/frequency of inspections. No critical activities should go without inspection!!
    - Epoxy coupler grouting
    - SCC closure pours
    - Bolting / field welding
    - UHPC joint casting
  - Increase inspectors since precast fabrication is on-site. There is no plant inspector!
  - Training program for inspectors specific to ABC construction activities

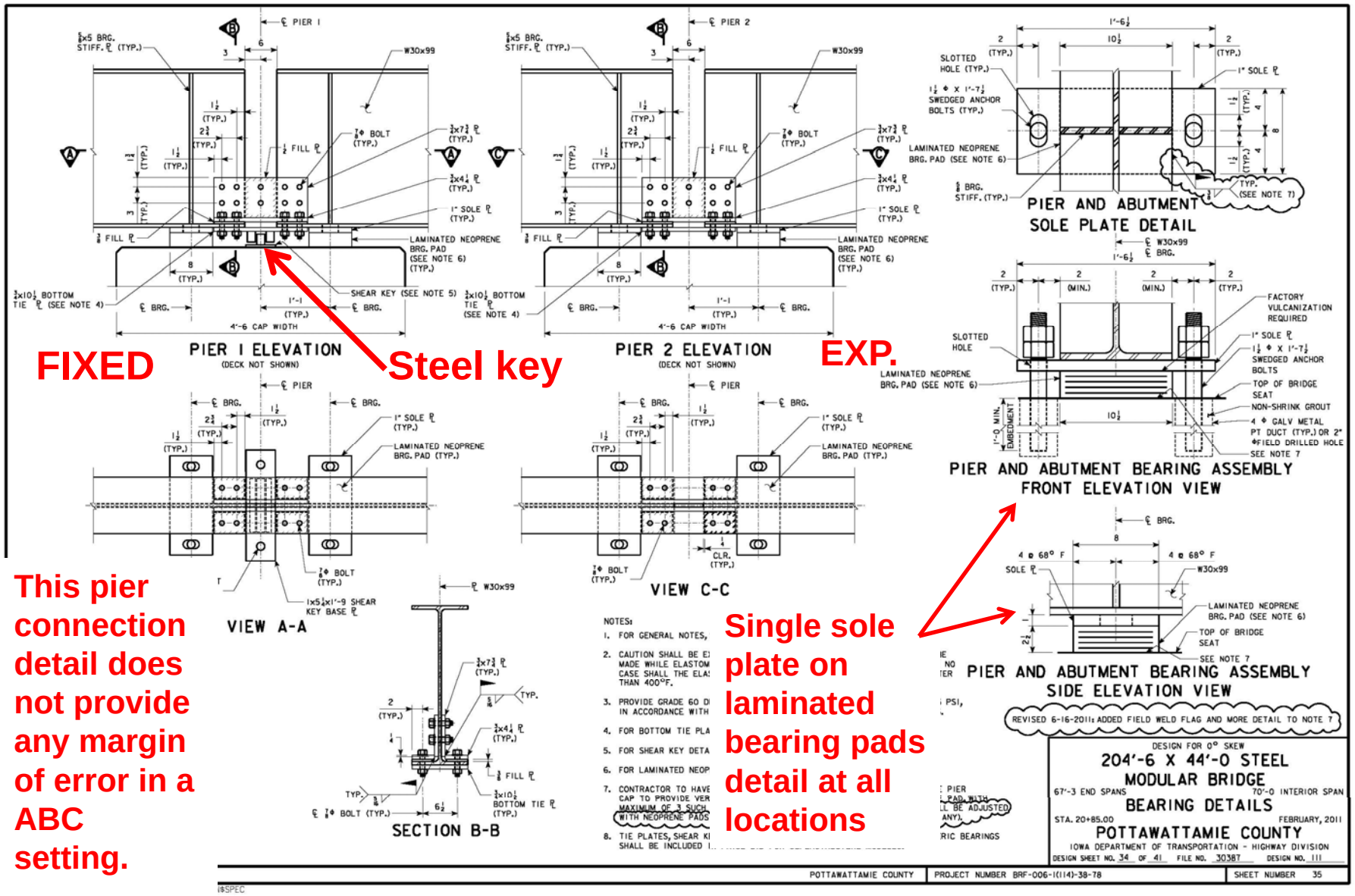
ABUTMENTS DETAILS



No easy way to attach the form for UHPC joint at the thermal gap

UHPC Placement in Backwall

CONTINUITY CONNECTION OVER PIER



This pier connection detail does not provide any margin of error in a ABC setting.

Single sole plate on laminated bearing pads detail at all locations

UHPC JOINT PERFORMANCE

- As of 2011, several bridge projects and some research projects had been conducted with UHPC being cast in the longitudinal joints (parallel to the bridge length).
  - Ben Graybeal at Turner Fairbanks tested a series of full scale 6” joints casted between deck panels.
  - UHPC has been cited to have enhanced bonding mechanism with other materials

HOW WILL JOINT UHPC PERFORM IN A TRANSVERSE JOINT ?

- The transverse joint over the pier is a region of high direct tensile strain in a bridge slab with continuity.
- To our knowledge, this had not been a subject of research for UHPC as of 2011.
- ISU conducted research on the UHPC transverse joint capabilities for live load continuity and to test the bond between the UHPC and deck concrete.
  - Report: *Laboratory testing of Ultra High Performance Concrete Deck Joints for use in Accelerated Bridge Construction*

  http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1445&context=etd
  - Report: *Laboratory and Field Testing of an Accelerated Bridge Construction Demonstration Bridge: US Highway 6 Bridge over Keg Creek*

  http://www.bec.iastate.edu/research/detail.cfm?projectID=1843325604

WHAT DID WE FIND OUT FROM TESTING?

- Under service II loading, the strain gages embedded in the UHPC joint and precast and surface mounted on the specimen measured significant displacements.
  - Indication the UHPC is debonding at the interface of the precast in the transverse joint.
  - This means potential to open up cracks in the deck.
  - The highest strain was across the joint interface.
- What did this mean for Keg Creek?
  - Retro-fit of continuity connection of the girders over the pier with high strength post-tensioning rods.

BRIDGE ENGINEERING CENTER

How is the superstructure designed?

- Conservative design assumption: simple for dead load with live load made continuous – same principle as PPCB bridges.
- Beam strength design is simple for dead and live loads
  - Each individual module can carry a full HS-20 truck , solely.
- Longitudinal deck bars intersecting the transverse joint transfer tension load over pier.
- Bottom splice plates at the pier transfers compression load from one module to the next.

Joint Forming

- Beveled construction joint
- Hairpin dowel bars need form holes
- Forms best to have mass production from a carpenter shop.

Joint Forming – LOTS OF FORMS!

- Fiberglass cast-in for cold joint to separate UHPC pours. Good Idea!
- Foam insulation to seal holes

COUPLER GROUTING

- Dayton-Superior “Sleeve-Lock Grout Couplers” with S-L grout
- Hand pump as recommended by D-S. (need backup pump)
- Do not start grouting until bedding grout has cured. Wait 12 hours

- Grout the bottom port. This will fill up bottom dowel chamber
- Grout will push out top. Install top plug while continuing grouting then install bottom plug
- Recheck and top off top plug

Column Installation Lessons Learned

- This is a critical ABC activity.
- Properly prepare and cure grout bedding
  - Overfilling the grout slightly
  - Provide a bedding grout dam
  - Curing the bed grout a proper time
- Have extra pumps and mixers available
  - Paddle mixers on-site are helpful.
- Project inspector must be on-site for bedding and coupler grouting activities. **THIS IS A MUST.**
- This method of construction for piers can be feasibly used in Iowa to build multiple span bridges.

Approach Slab Lessons

- Backfill process will be on critical path on 14 day ABC schedule. (Can’t backfill until modules placed)
- This will make it difficult to pour all UHPC on the same day for deck and approach slabs.
- Contractor installed West precast approach slabs on day 13 putting them behind.
- Contractor suggested using traditional cast-in place approach with a m-mix pavement would probably speed along the process.

Future Design Improvements for Modular ABC

- For UHPC joints, the Exposed Aggregate method for texturing the edge of precast is the preferred method as recommended by UHPC suppliers and research.
- If using alternate form liner method for texturing precast edge, use stainless steel rebar across the joint so that the precast edge can be sandblasted to enhance bond with UHPC.
- Use straight dowel bars protruding into UHPC (not hairpins).
- Use a compression block detail (not a bolted plate connection) for the bottom flange continuity at the pier. Compression block would require less precision in erection.

Future Design Improvements for Modular ABC (cont.)

- Use a wider transverse joint at the pier to limit the magnitude of tension on the deck joint interface with CIP pour.
- For substructure and approaches, provide a design alternate in the project plans for cast-in-place with high early strength concrete mix to accelerate the cure. A pre-tied rebar cage can be used with the CIP to accelerate method.
- Most of these details utilized for IA 92 over Little Silver Creek ABC project.