SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

SHRP2 Project R04

Part 2 – Everyday Solutions: Application of SHRP2-Developed Tools in Case Studies

Bala Sivakumar

HNTB Corp.

Feb 16, 2012

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

SHRP2 Project R04

INNOVATIVE BRIDGE DESIGNS FOR RAPID RENEWAL

2008 -- 2013

HNTB (Prime)

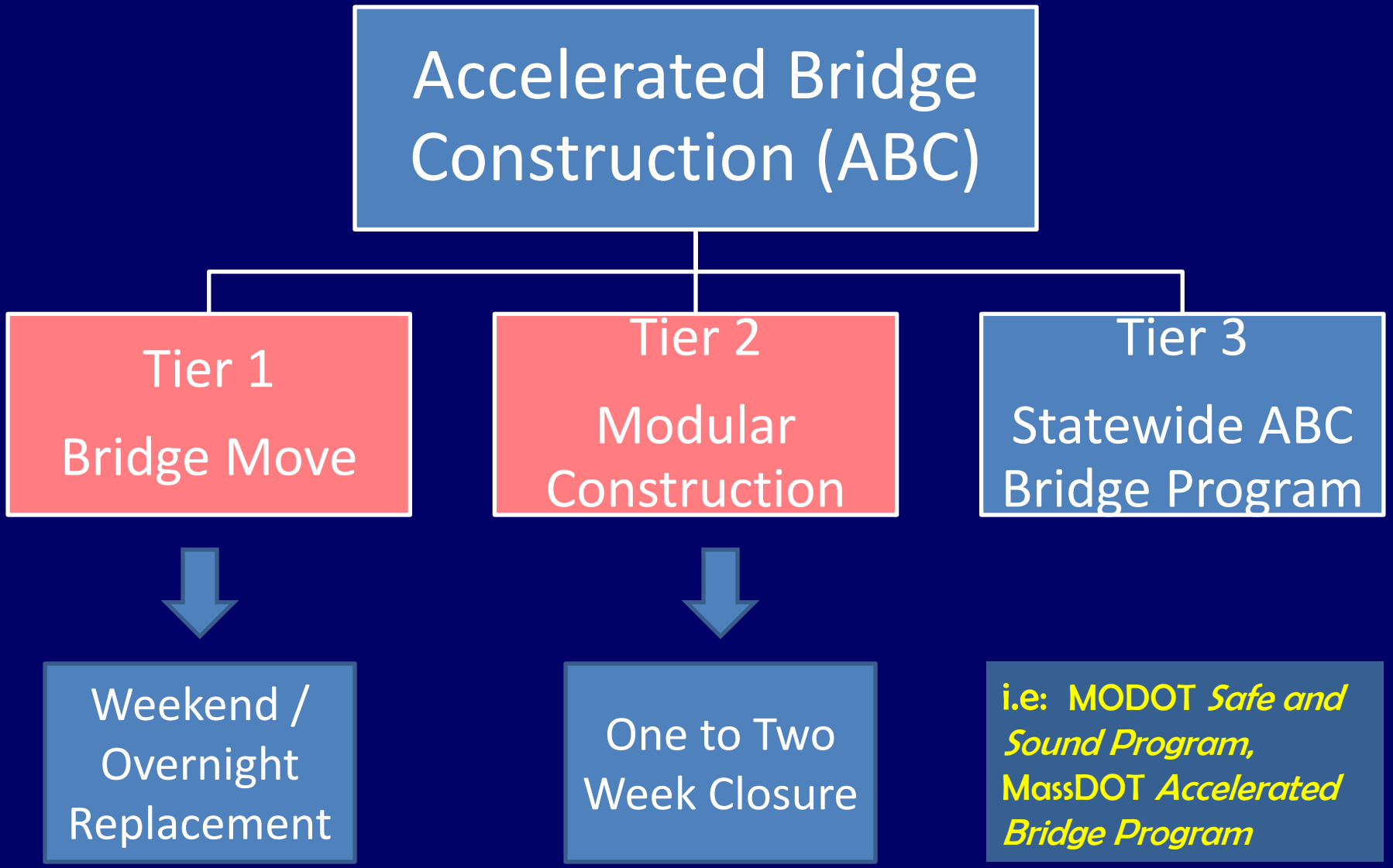
Iowa State University

Structural Engineering Assoc.

Genesis Structures

Dr. Monica Starnes, Senior Program Officer SHRP2

SHRP2 -- Tiers of ABC Concepts



SHRP2 Project R04

Phase I – Define ABC Challenges

Phase II – Identify & Refine the Best ABC Technologies

Phases III A – Develop ABC Design Standards

Phase III B – Demonstrate ABC (Modular Construction)

Phase IV – Demonstrate ABC (Bridge Move)

SHRP2 R04 ABC Demonstration Project #1
Modular Construction (IADOT)

Oct 17, 2011

14 Day ABC Period

Keg Creek Bridge

Nov 1, 2011

SHRP2 R04 ABC Demonstration Project #2
Lateral Slide (NYSDOT)

2012 Construction
Overnight replacement

I-84 EB & WB Bridges
over Dingle Ridge Road

ABC Demonstration 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
- Redesigned for ABC by SHRP2 R04 Team
  - Modular construction
  - 14 day ABC period (Road closure)
- Selected by IADOT as ABC candidate
- Project needed to fit timing for R04 project
- Highway / civil design by IADOT

Bids

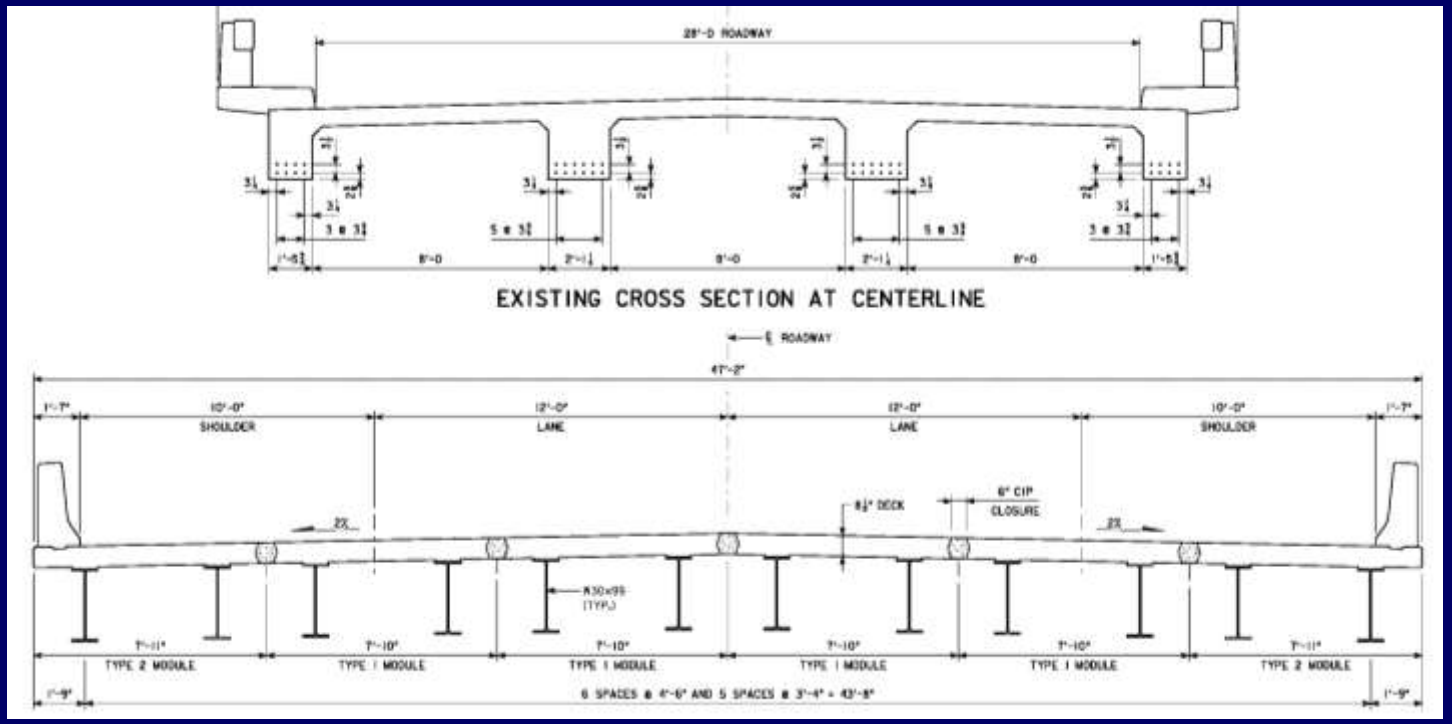
- Seven local bidders
- Contract letting: Feb 2011
- Contractor: Godbersen-Smith Construction, Ida grove, IA
- Low Bid: $2.67 Million
- Bridge cost = $231 / SF
- Incentive / Disincentive = $ 22000 / day during 14 day ABC period
- HFL funds $600,000; SHRP2 funds $250,000

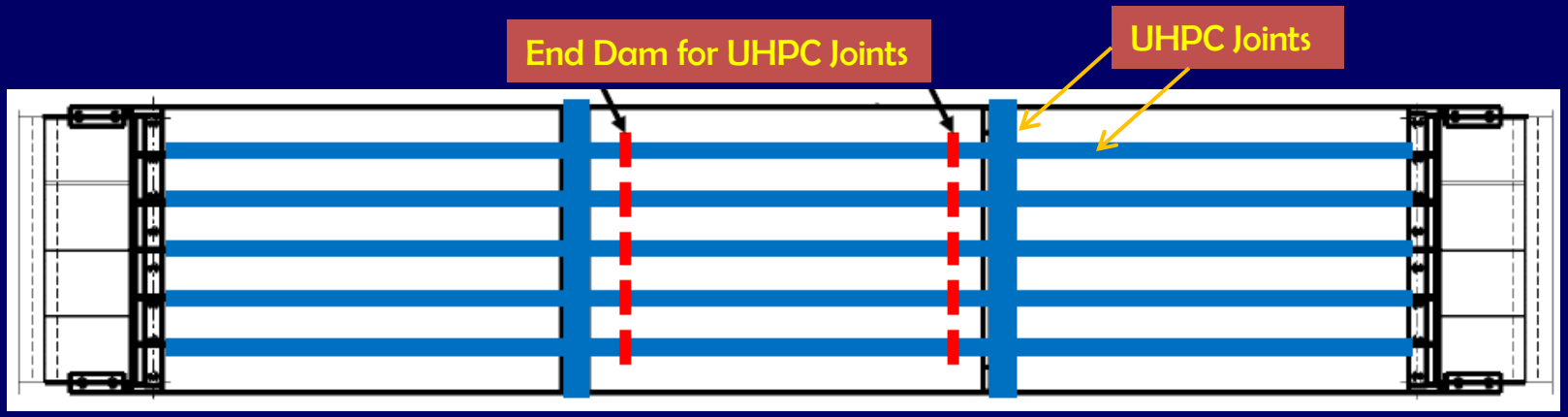
US 6 Keg Creek Bridge
Site Layout

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)

Cross-Sections / Plan





ABC Highlights

- Complete prefabricated bridge, including approach slabs
- UHPC, SCC, Grouted splice coupler connections for rapid field assembly
- HPC concrete. No open joints
- First bridge in 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)

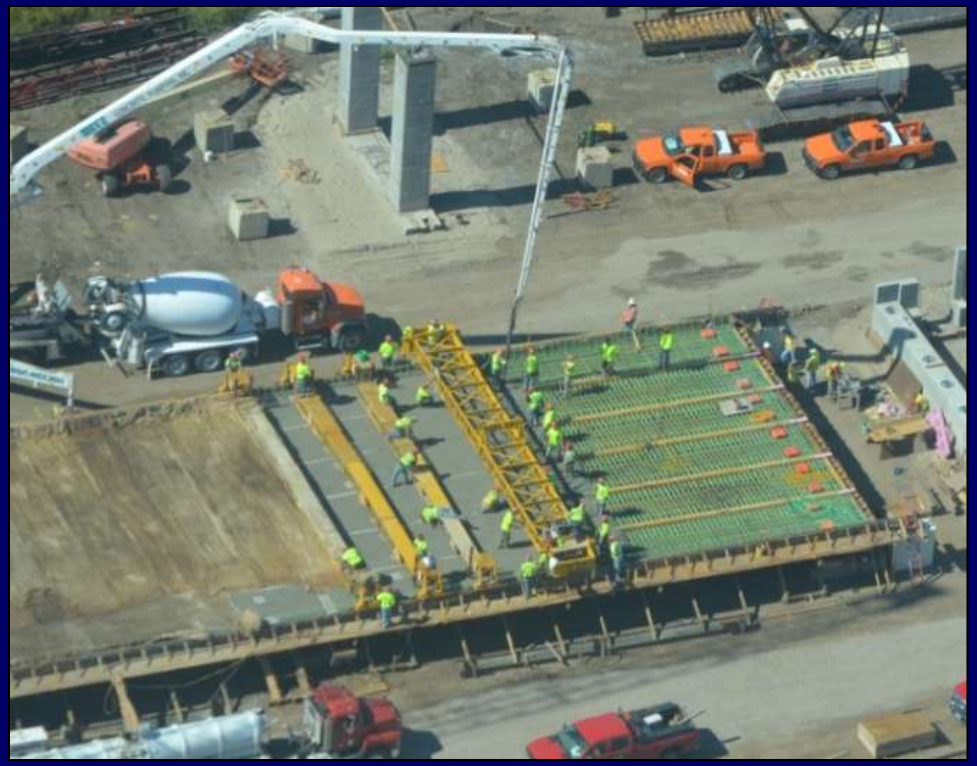
Stage 1 (Pre-ABC)
Drilled Shafts Foundations

- 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)

Prefabrication of Abutments and Piers

Prefabrication of Steel Modules



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

Stage 2 (ABC Period)

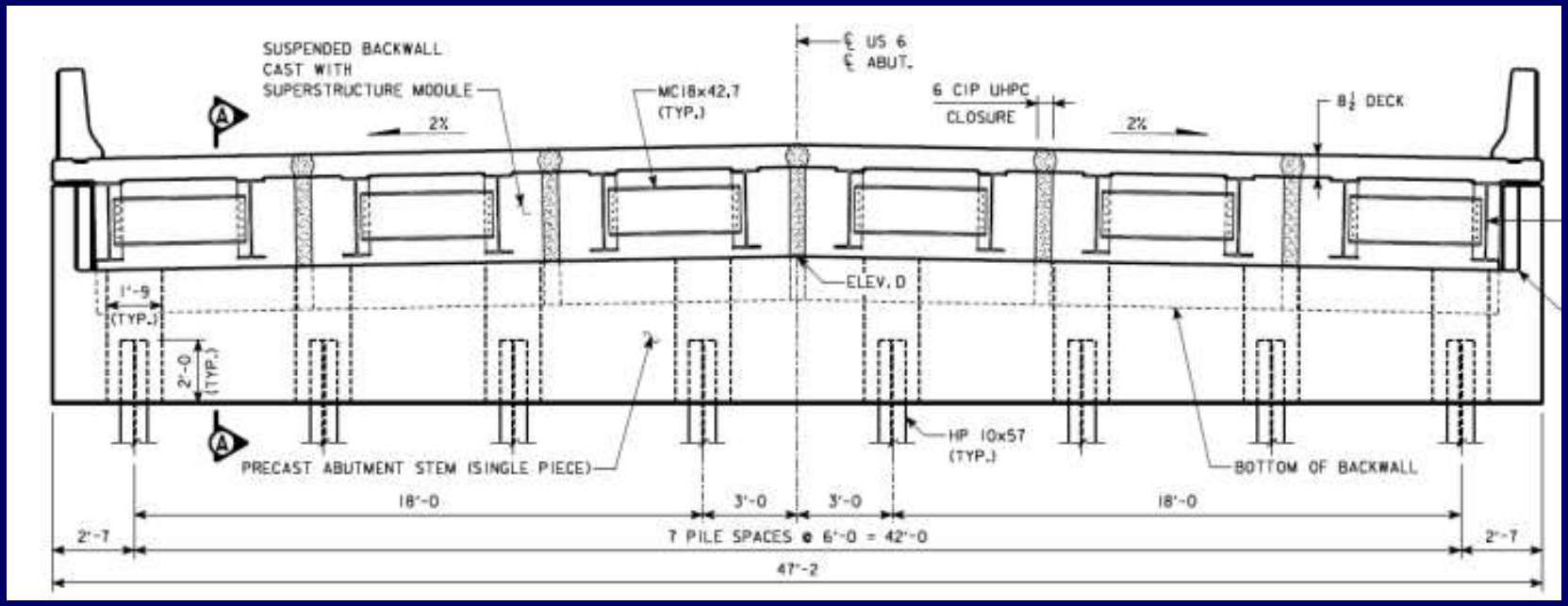
Rapid Demolition

Day 1

Oct 17

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

Precast Abutment Details



Precast Abutment Construction

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

Precast Abutment Assembly

Days 3 & 4

Precast Wingwalls Assembly

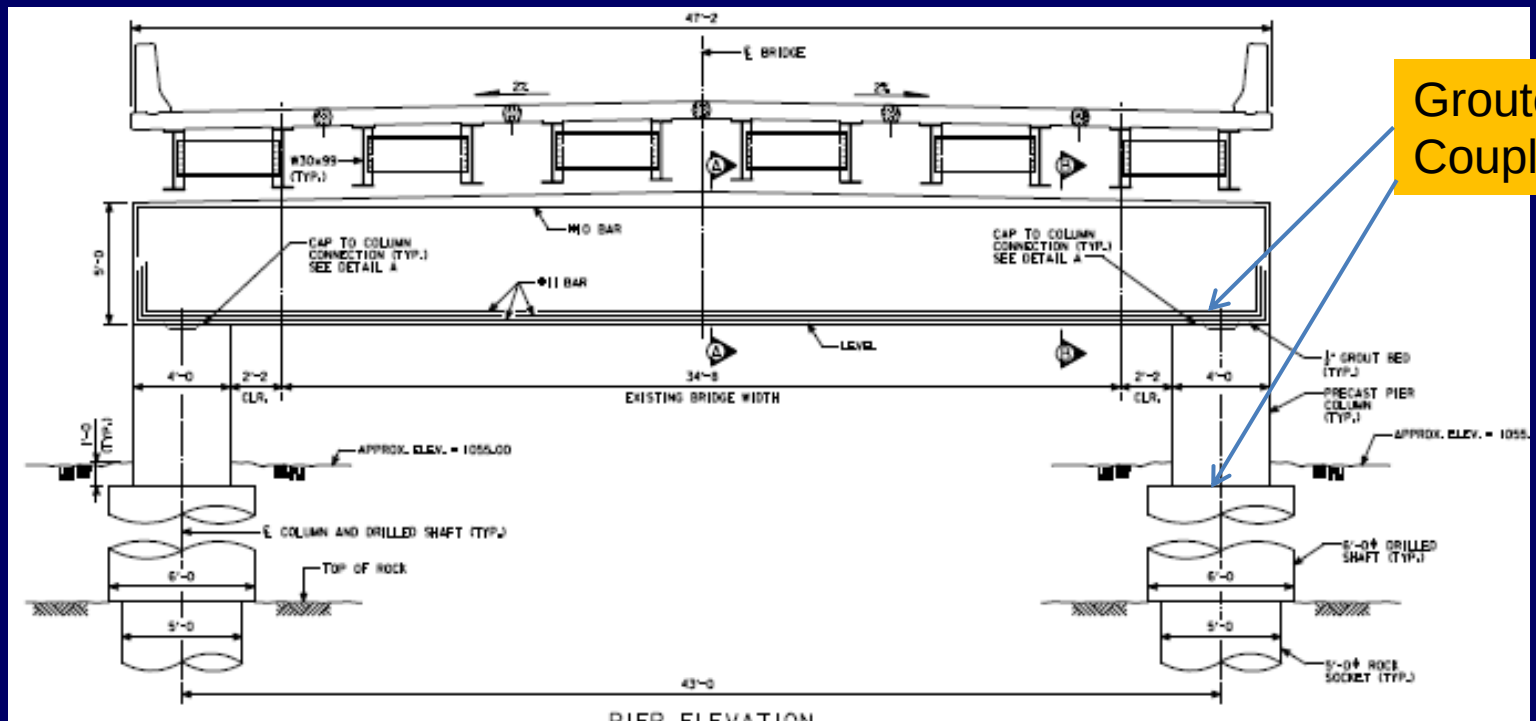
Day 4

Self Consolidating Concrete Joints

Precast Piers – Straddle Bents

Days 4 & 5

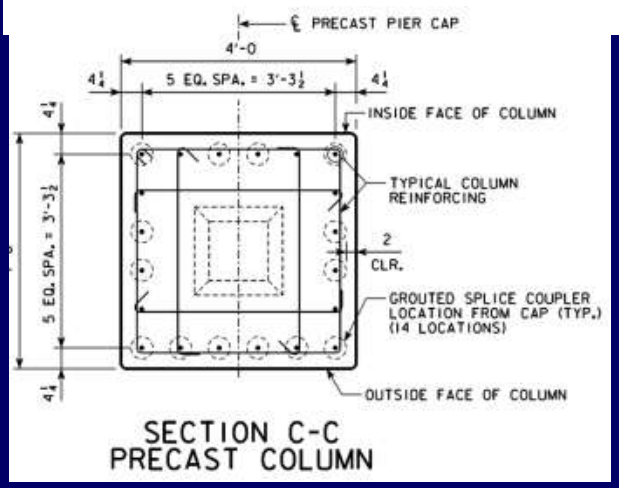
Precast Piers

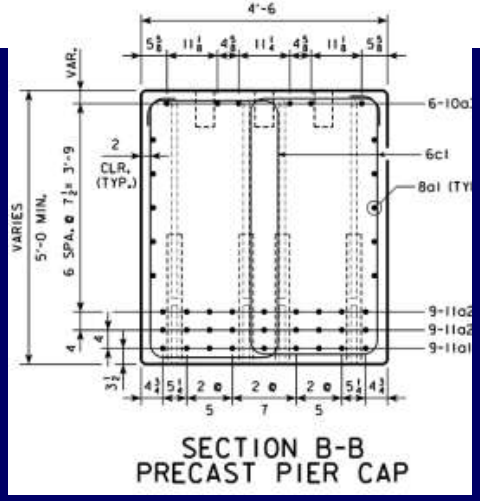


Grouted Splice Couplers

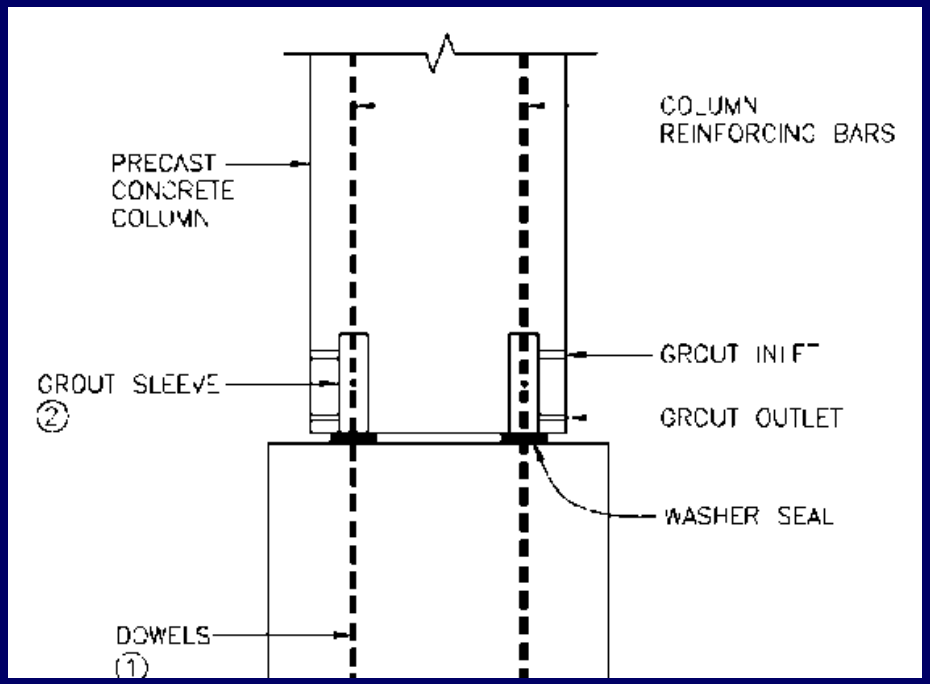
RCC Design

Voids in Cap Beam





Grouted Splice Coupler

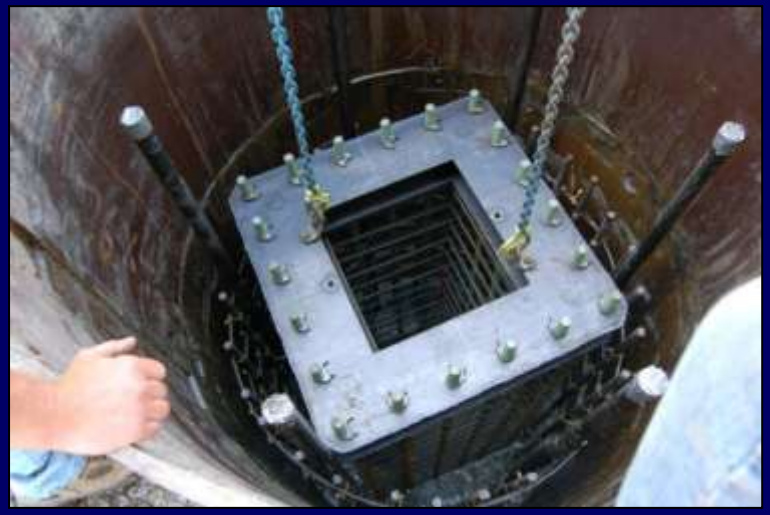


- Use in low seismic areas only
- Drilled shaft to column connections
- Column to cap connections
- Fast assembly

Precast Columns

Day 4

Template for Dowels

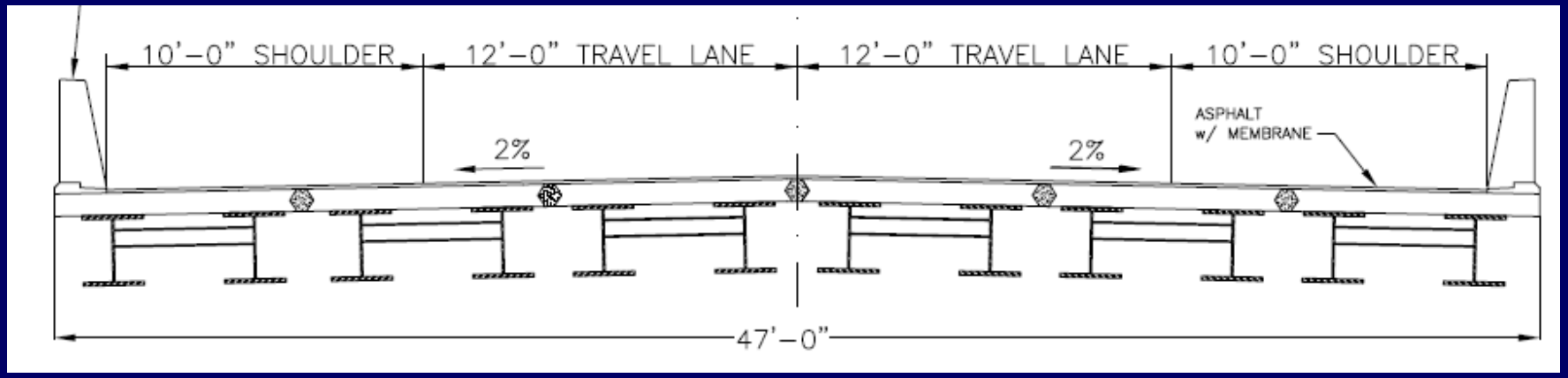


Precast Pier Assembly

Day 5

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

Modular Superstructure Systems



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

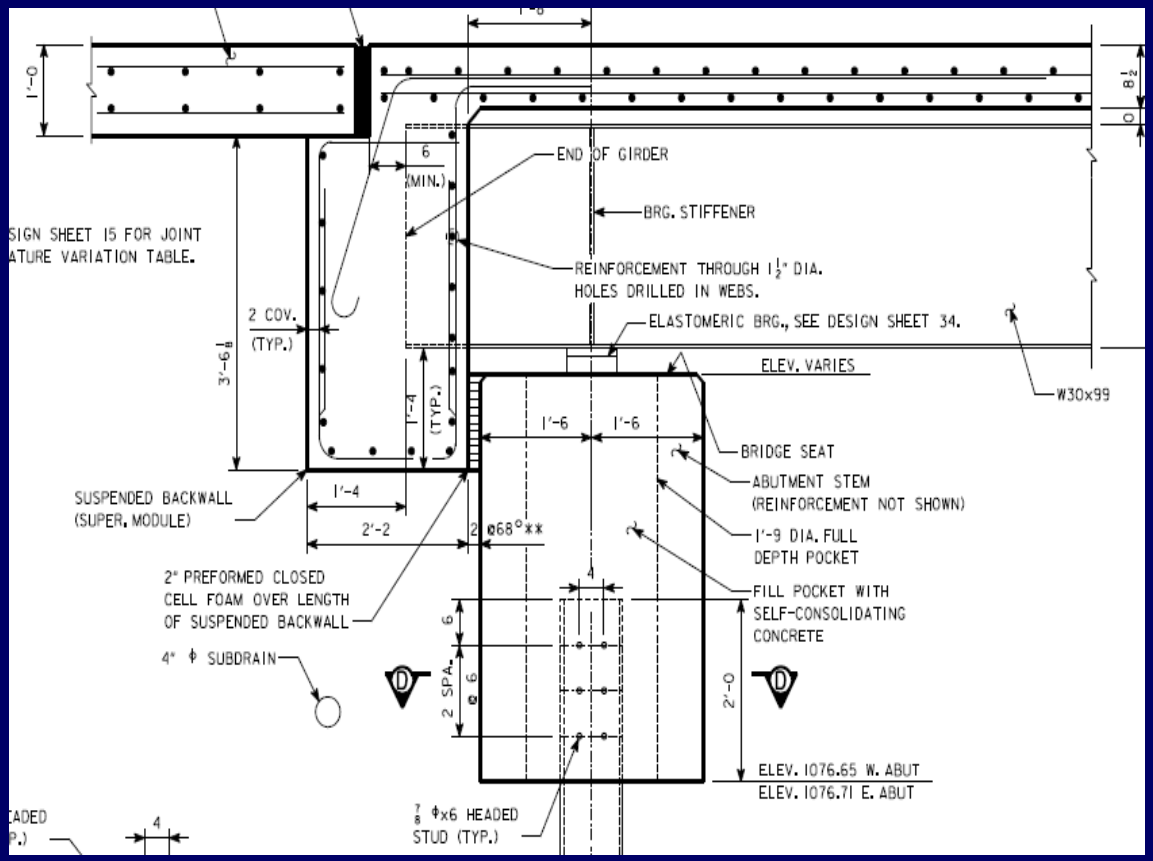
Erection of Superstructure Modules

Days 7 & 8

Span = 70 ft

Semi-Integral Abutment
Suspended Backwall

Days 7 & 8

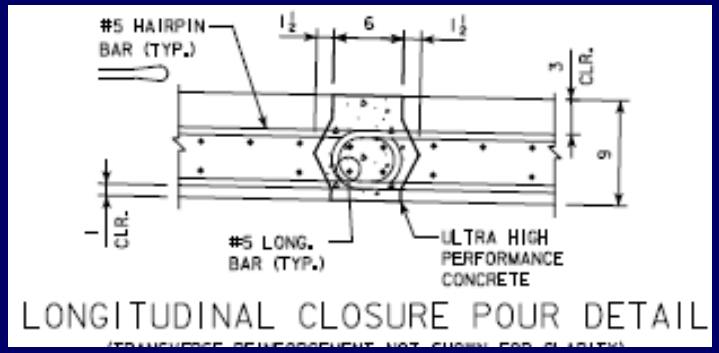


- Allows superstructure expansion / contraction
- Easy fit up
- Well suited for rapid construction

UHPC Joints in Bridge Deck

Day 10

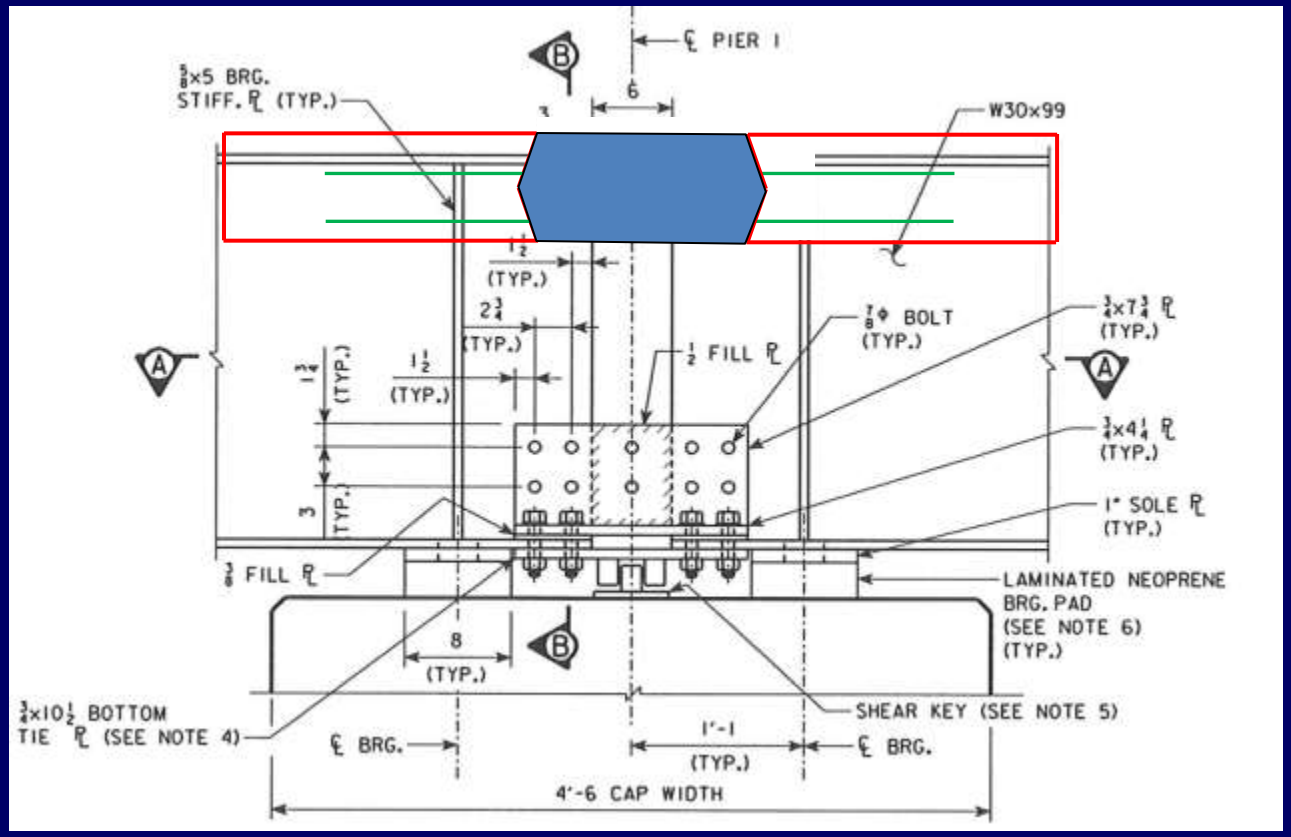
- Full moment transfer. No post tensioning required
- Only 6 in wide. High strength; low permeability
- Can be reinforced with hairpin bars or straight bars



(Longitudinal Joint)

Day 10

Transverse UHPC Joints at Piers

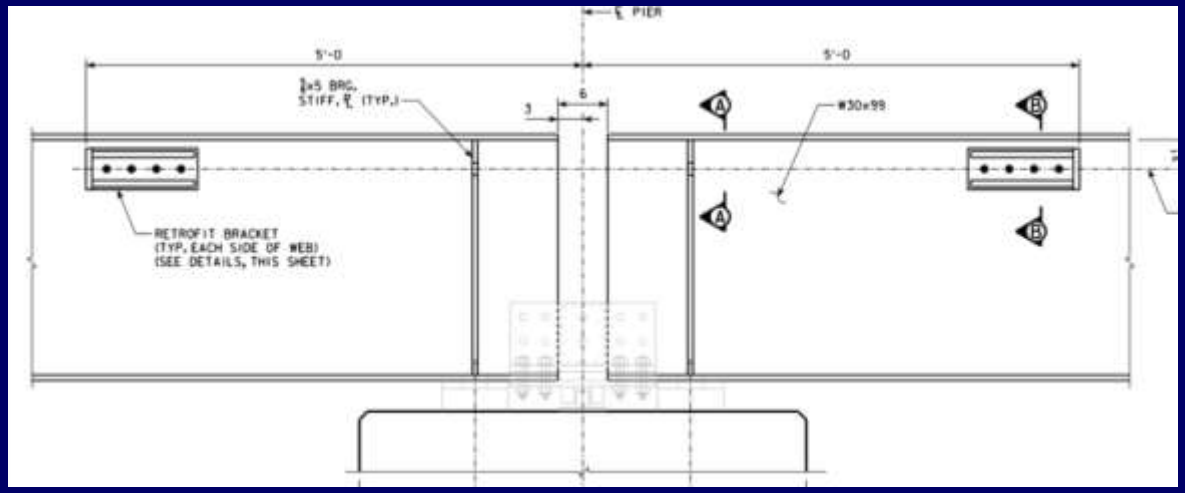


- UHPC joint reinforced to carry the full LL tension
- First use of UHPC for transverse joints over pier

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

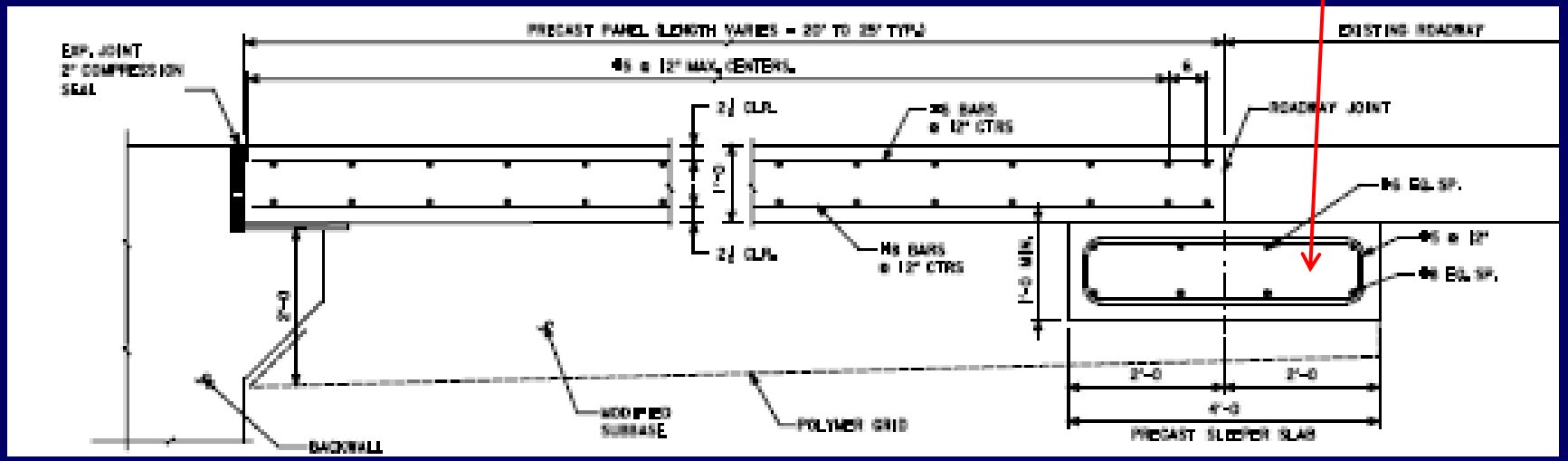


- 1 inch H.S threaded bar post-tensioned to 70 Kips
- Prevent deck cracking under service loads
- Keep bond between UHPC and HPC deck in compression

Precast Approach Slab

Day 10

Precast Sleeper Slab



Day 13

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.

Oct. 17th

Oct. 21st

Oct. 22nd

Oct. 24th

Oct. 28th

Nov 1, 2011

Keg Creek Video:
One Design—10,000 Bridges

SHRP2 Website

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

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.

SHRP2 R04
Phase IV 2012

Bridge Movement Techniques for ABC:

- Lateral sliding;
- Longitudinal Launching;

- Self Propelled Modular Transporters (SPMT);
  (Ref: FHWA SPMT Manual
  UDOT SPMT Manual)

Second ABC Demonstration 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

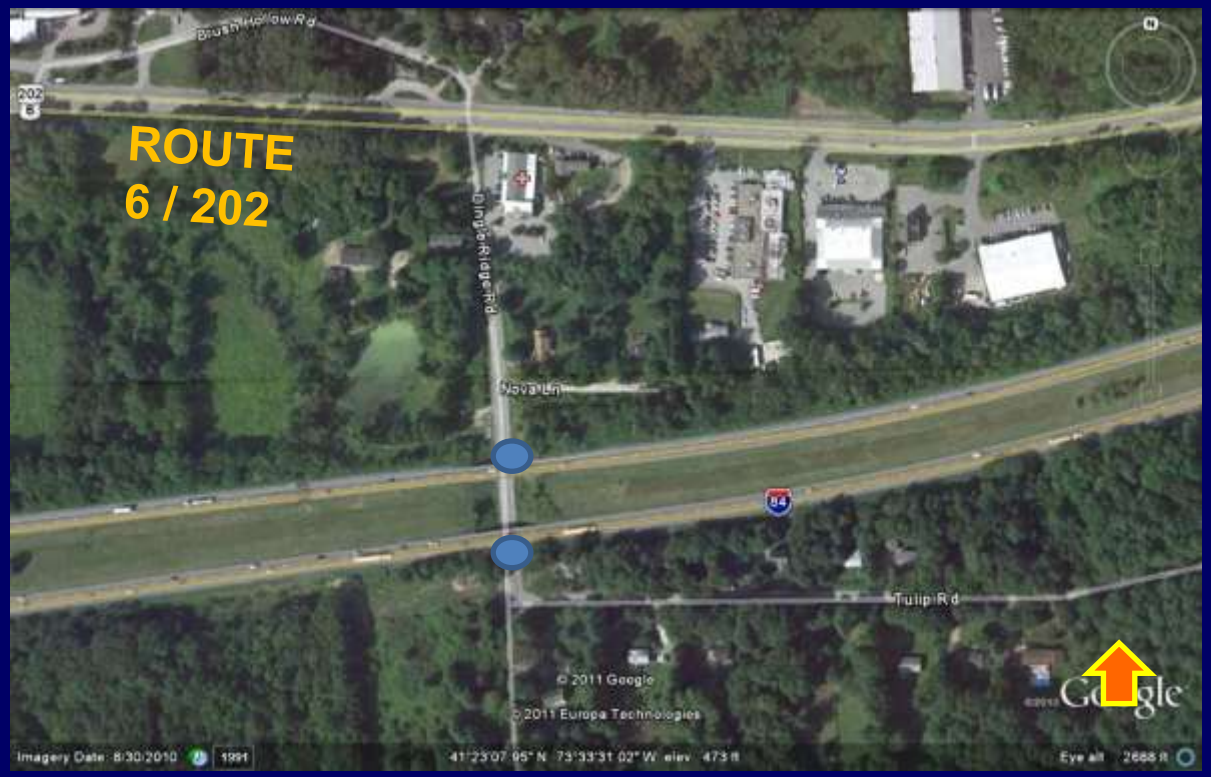
- Eliminates need for a temporary bridge & cross-overs
- Traffic disruption on I-84 reduced from two years to two weekend nights (16 - 18 hr closures).
- Dingle Ridge Road (low volume) will be closed longer to complete the demolition.
- Slide-in new single span concrete superstructure and approach slabs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

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

Traffic Control During Construction

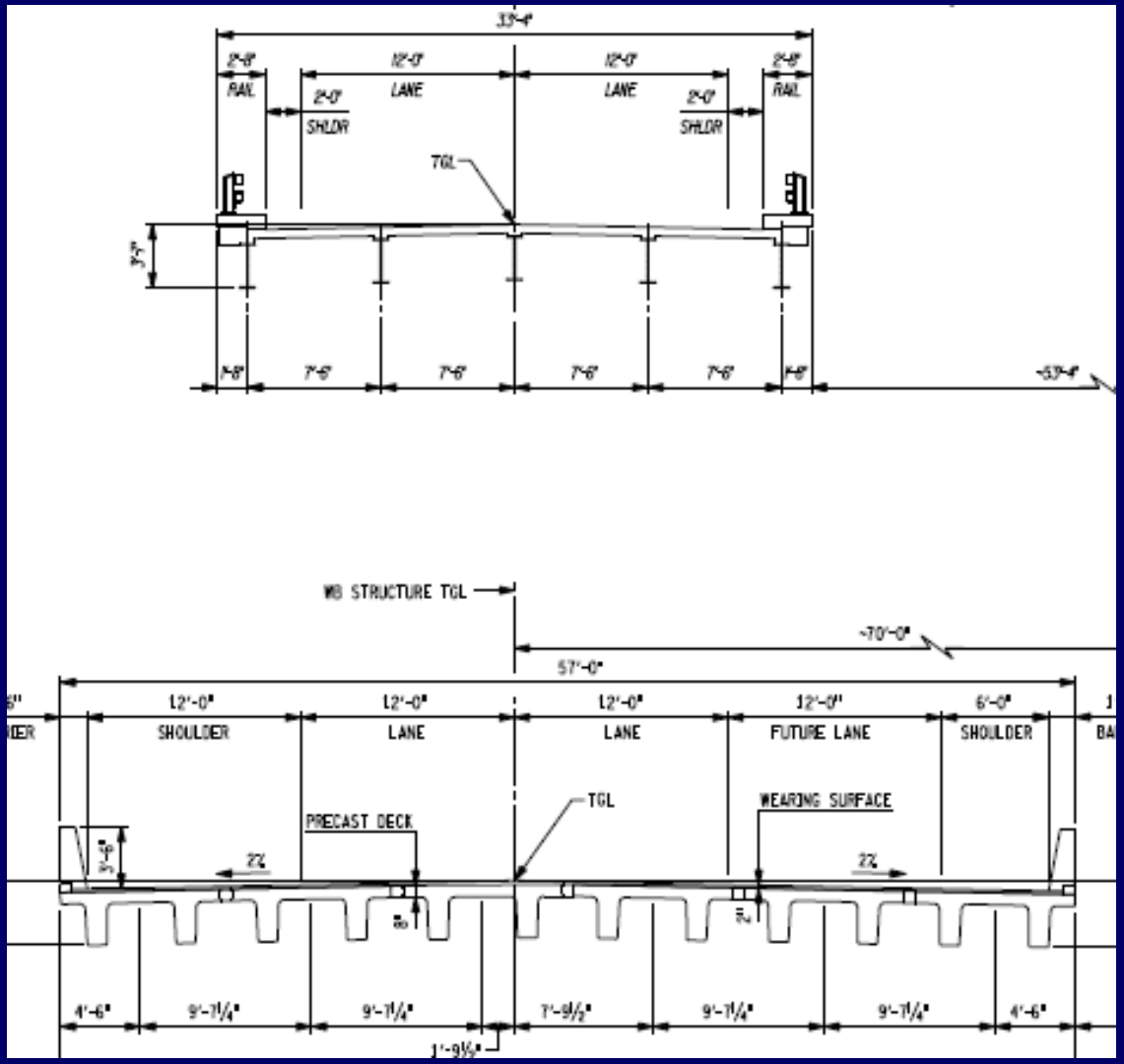
- Traffic on I-84 will be maintained during substructure work
- Detour will be in place for only 16-18 hours for the removal of existing bridge and slide in of the new
- Detour during Saturday night -- Sunday morning
- Route 6/202, parallel to I-84, will be used as the detour.



ABC Design - New Bridges

- Single span 80’; Three lanes at 12’
- Left shoulder 6’, right shoulder 12’
- Bridge width 33’-4” ⇨ 57’-0”
- Provides room for future traffic control
- Use 2” 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

Typical Sections



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

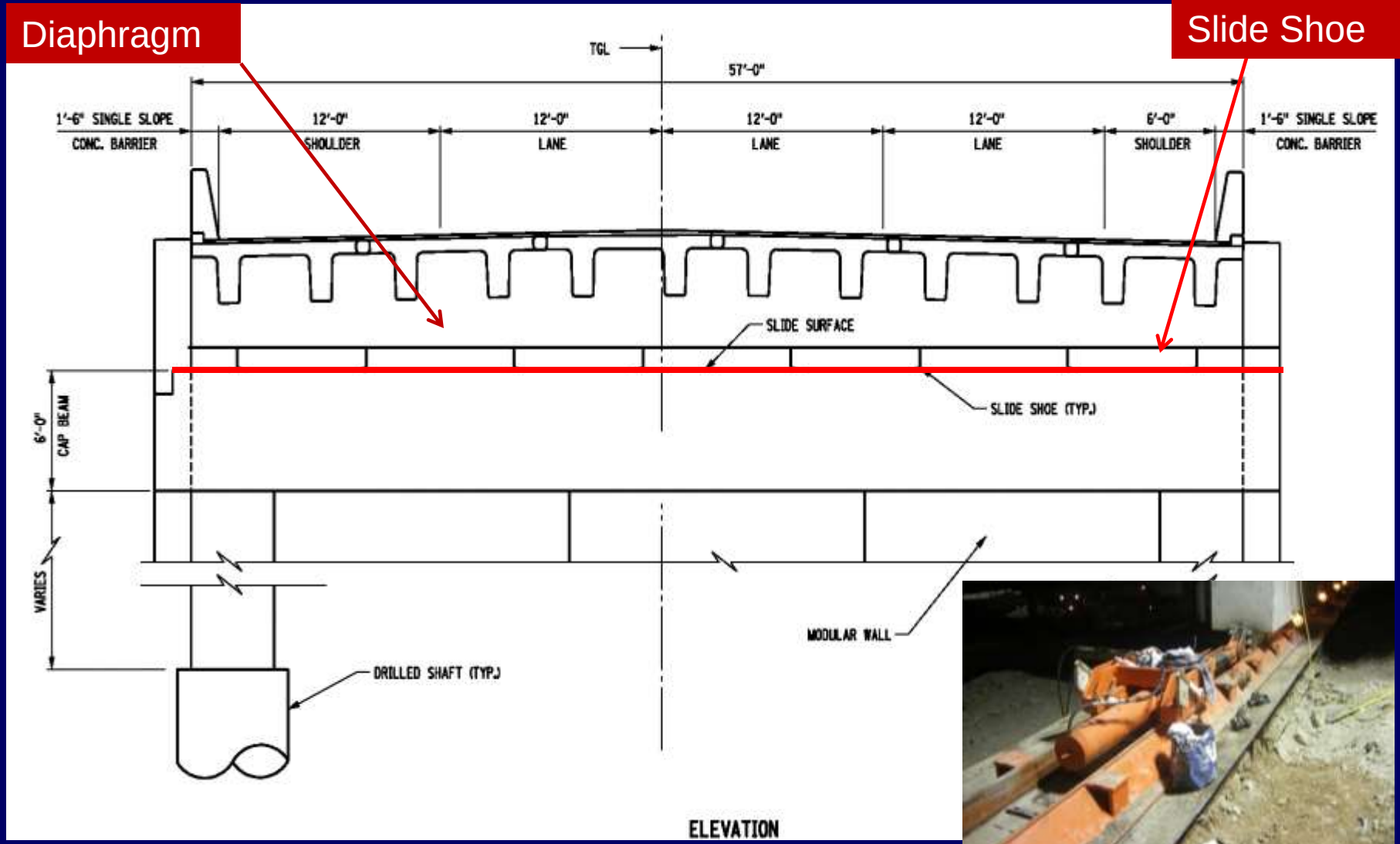
ABC Design Challenges

- 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

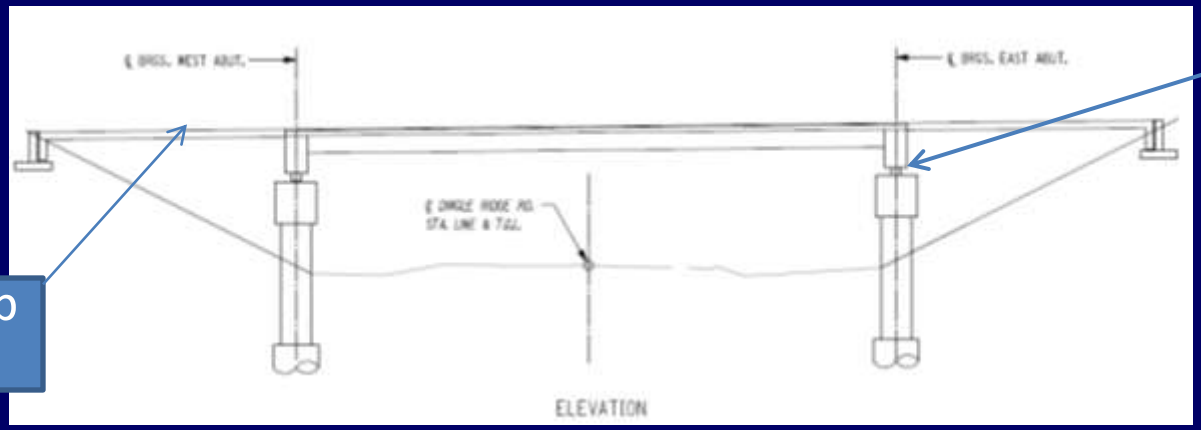
Straddle Bent Abutment
w/ modular retaining walls

Diaphragm

Slide Shoe



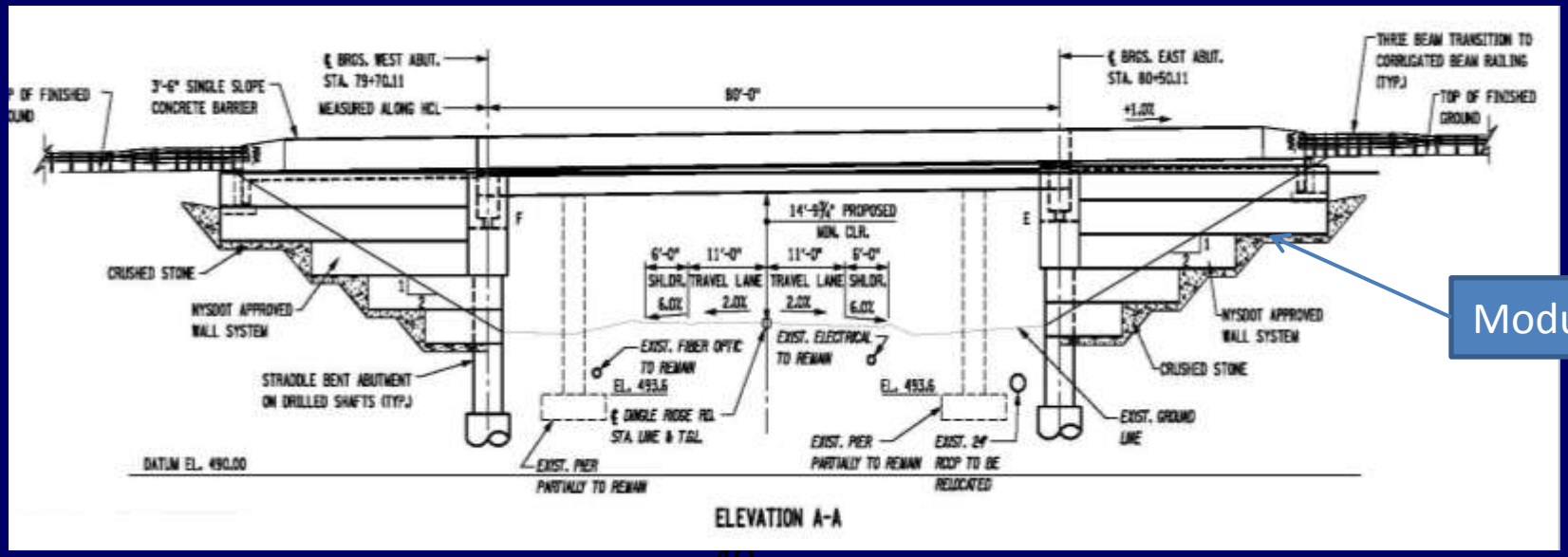
Longitudinal Elevation



Slide Surface

Temp. jump span

During Slide

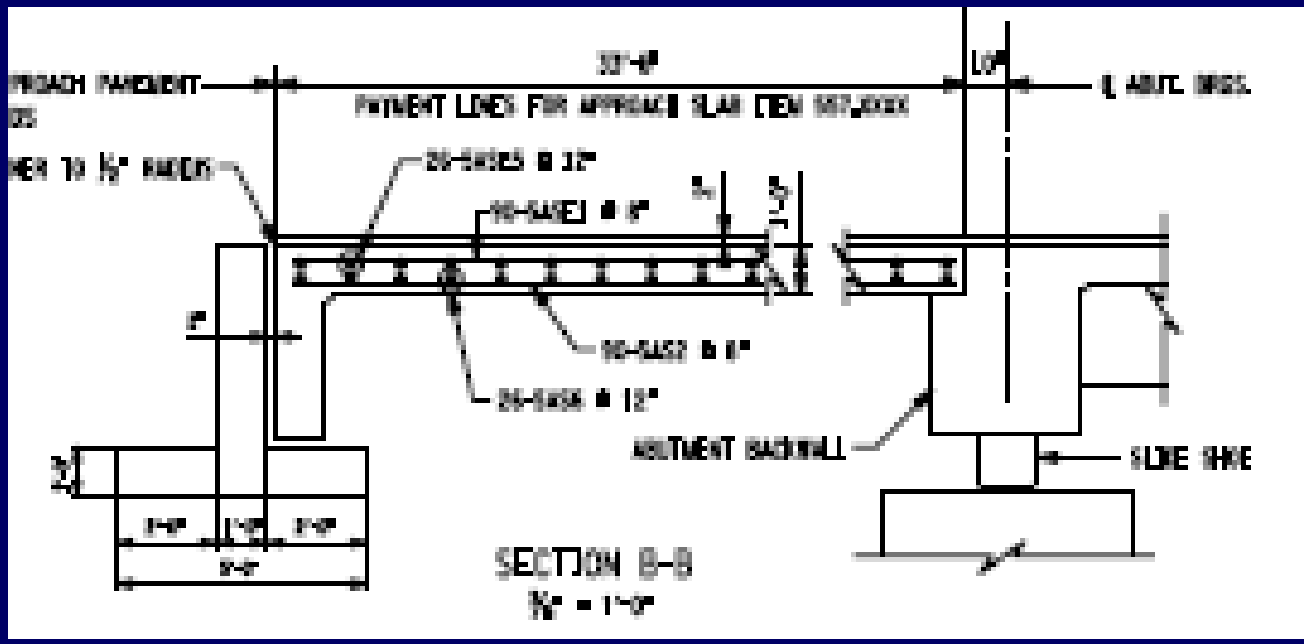


Modular walls

Final (complete modular walls after reopening)

Sleeper Slab / End Dam

End dam will retain the approach pavement that will be raised by 2 ft during ABC period.



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

ABC Benefits

- **Construction duration** 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

SHRP2 Project R04

Questions ?