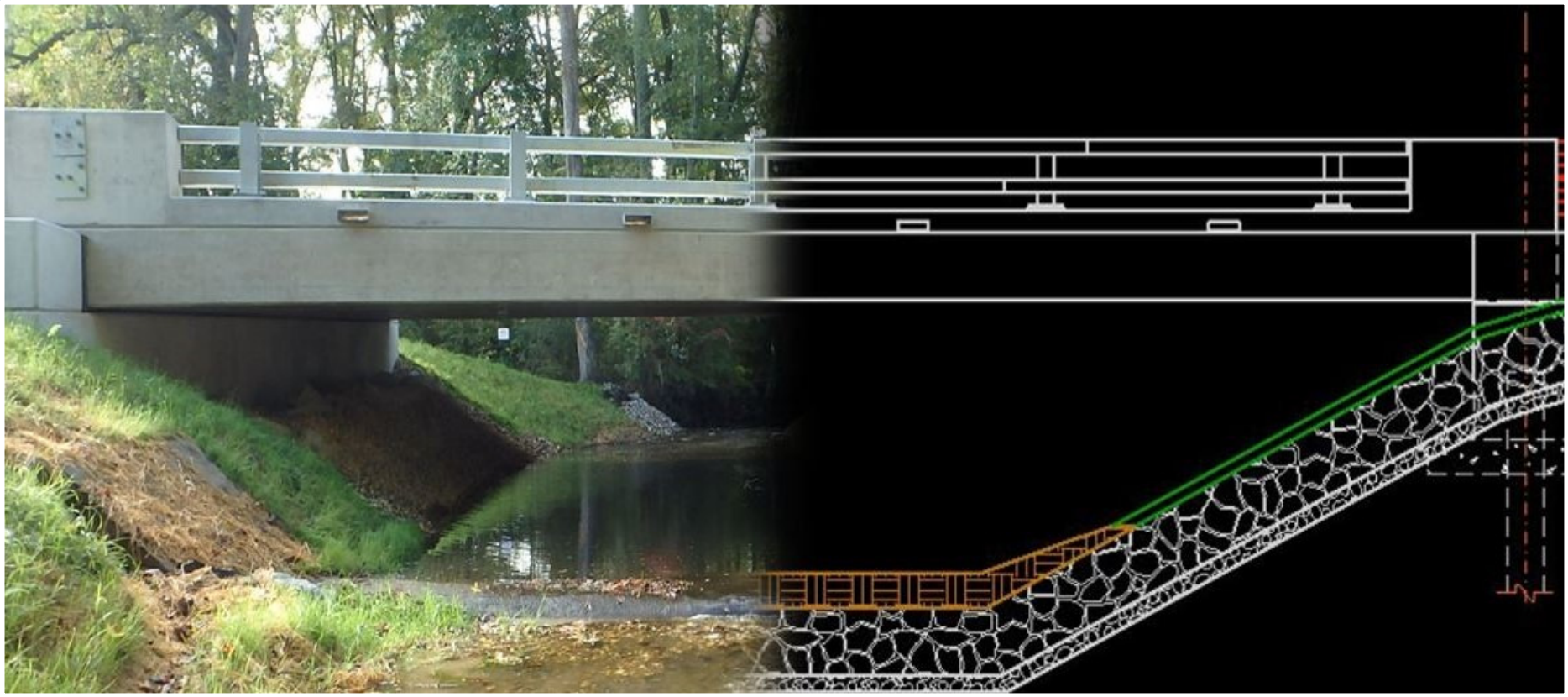
Accelerated Bridge Construction Methods for Bridge 1-438

Craig Stevens, P.E. & Nicholas Dean, P.E.
DelDOT Bridge Design



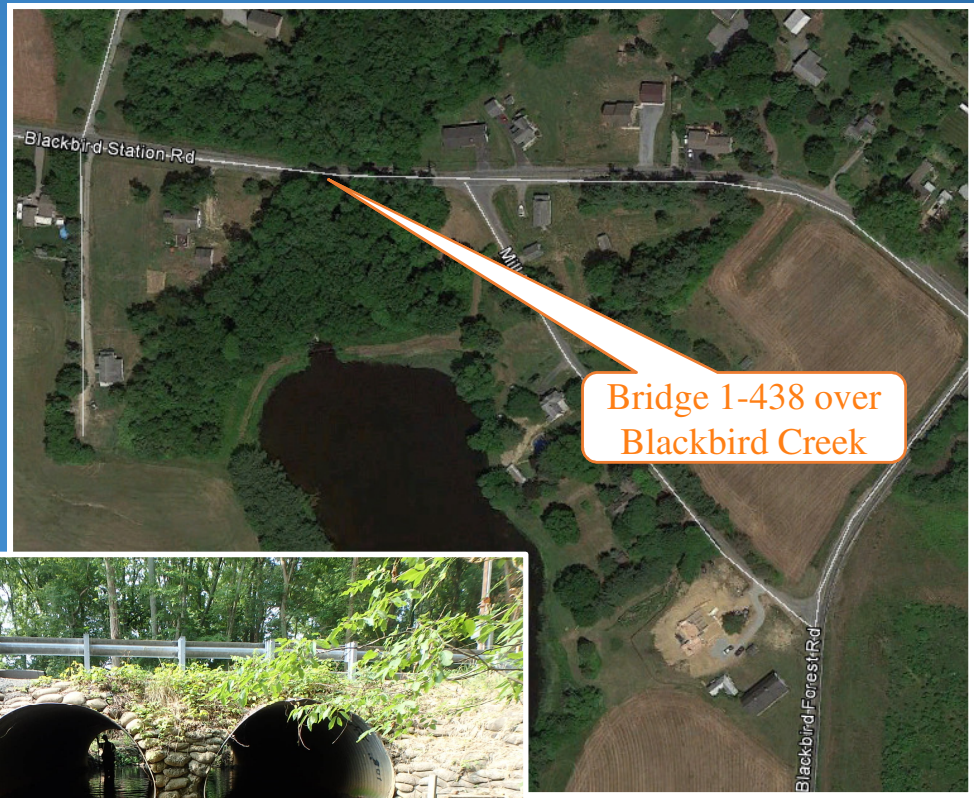
ZACK EXCAVATING INC.

DEPARTMENT OF TRANSPORTATION UNITED STATES GOVERNMENT

DelDOT BRIDGE SECTION

Existing Site Conditions

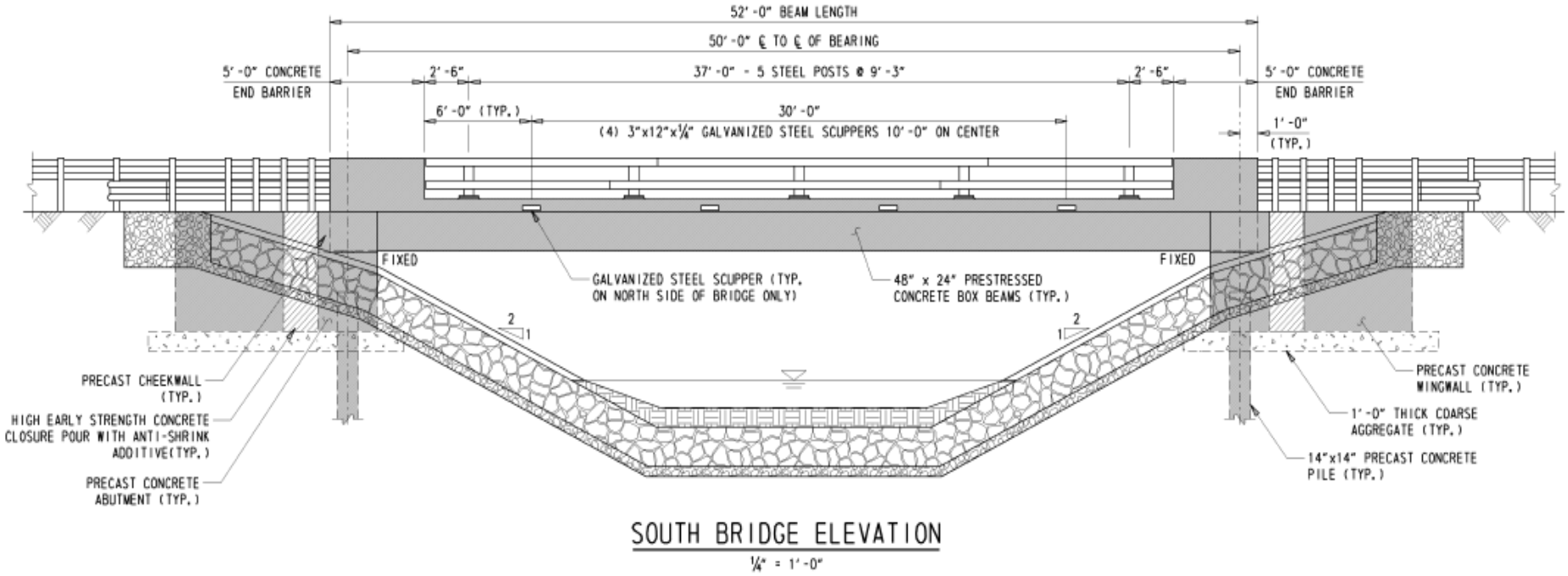
- N463 Blackbird Station Road, Townsend, DE
  - A.A.D.T. : 1,700 vehicles
  - Design Speed: 40 mph
  - Horizontal & Vertical curve
- Existing Bridge 1-438
  - (2) 7'-0" High x 10'-8" Wide Corrugated Metal Pipe Arch
  - Poor conditions at top of soil profile



DelDOT Bridge Section

Replacement Solution

- Adjacent Box Beams (50’-0” Span)
- Stub Abutments & Cantilevered Wingwalls
- Prestressed Concrete Piles



DelDOT Bridge Section

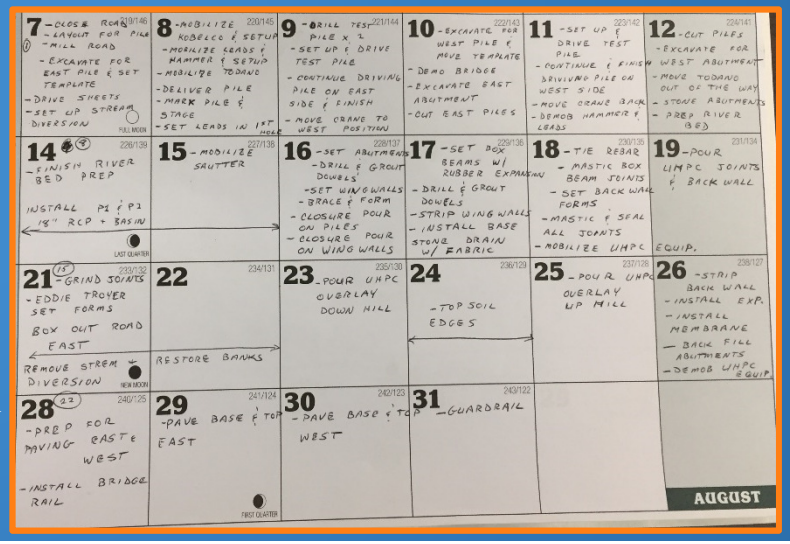
Why ABC?

- FHWA's Every Day Counts Initiative
- Department Commitment to Innovation
- Ideal Pilot Project Location

DelDOT Bridge Section

ABC Methods Implemented

- Entirely Precast Bridge Elements
  - 1st in Delaware
- Ultra High Performance Concrete (UHPC) Transverse Connections
  - 2nd adjacent box beam project to utilize UHPC in Delaware
  - Now DelDOT Standard Practice
- UHPC Overlay
  - 1st in Delaware & 2nd in United States
- Scheduled Construction Duration: 33 Calendar Days
  - World's Most High-tech CPM



DelDOT Bridge Section

Precast Prestressed Concrete Piles

- 14” x 14” concrete piles
  - Test Piles: (2) 50’-0” long
  - Production Piles: (10) 45’-0”
- Lead Time for Piles
  - Test & Production Piles ordered at same time
  - Resulted in weeks of time savings
- Pile Template
  - Tighter Tolerance
  - Precise Locations
- Installation Time
  - 2 Consecutive Days
  - 6 Hours per Side

DelDOT Bridge Section

Precast Abutment Sections

- (4) Precast Sections
  - 23’-0” Long Sections
    - Section 1 & 3: 28.12 Tons
    - Section 2 & 4: 23.14 Tons
- Major Challenges
  - Accommodating Skew
  - Precasting voids
  - Missing Dowel Sleeves
- Installation Time: ~1 Hour Total

DelDOT Bridge Section

Abutment Closure Pour

- Class I Concrete
  - 4,500 psi Compressive Strength
  - 2% High Early Strength Admixture
- Timing was Essential
  - 50% 28-Day Compressive Strength
  - Loaded Abutments within 24-Hours

DelDOT Bridge Section

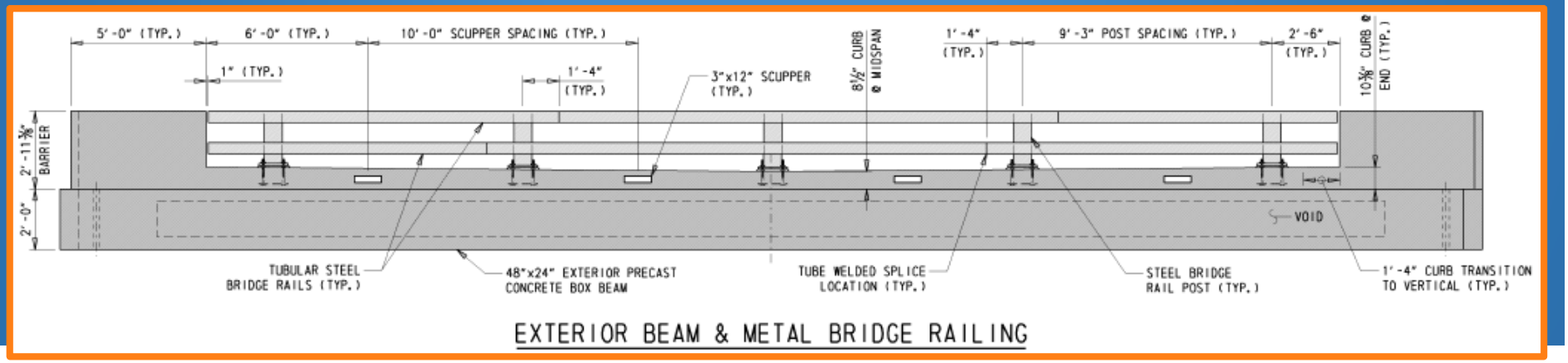
Precast Wingwall Sections

- (4) Precast Sections
  - North Sections
    - 6’-1” wide x 6’-2” high
    - 2.82 tons
  - South Sections
    - 6’-1” wide x 8’-2” high
    - 3.73 tons
- Cantilevered off Abutments
  - No Footer
  - Minimized Excavation
- Installation Time:
  - ~½ Day Set & Perform Closure Pour
  - 2 Days to Pull Formwork

DelDOT Bridge Section

Precast Adjacent Box Beams

- (10) 52’-0” Long 24” x 48” Girders
  - Exterior Girders
    - Caltrans Precast Bridge Rail
    - 16 Prestressing Strands
    - 28.43 Tons
  - Interior Girders
    - 14 Prestressing Strands
    - 19.97 Tons
- Major Challenges
  - Differential Camber
  - Crash Tested Barrier System
- Installation Time: 1 Day



EXTERIOR BEAM & METAL BRIDGE RAILING

DelDOT Bridge Section

UHPC Joints & Backwalls

- Previous Issues
  - Reflective Longitudinal Cracking
  - Leaking
- New Shear Key Detail
  - Developed by FHWA
  - Eliminates:
    - grouted keyways
    - welded shear connector plates
    - Post tensioned tie rods
- Precaster Modified Shear Key Reinforcement
  - Skewed Bars
  - Eliminated 3 Bars

DelDOT Bridge Section

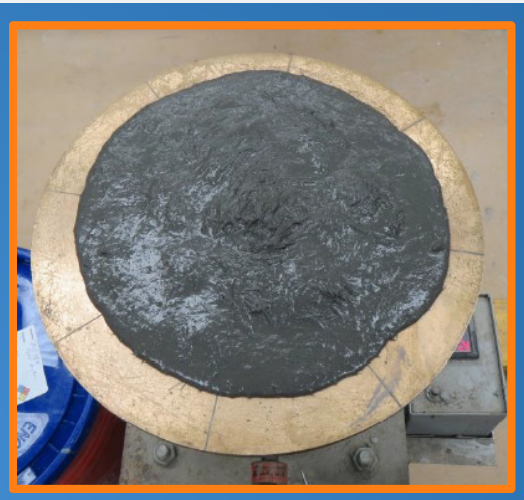
UHPC Joints & Backwalls

- Joint Preparation/Formwork
  - Mastic used to seal joints
  - Formwork for Backwall
  - Cleaned Joints
  - Saturated Surface Dry (SSD) Condition?
- UHPC Pour
  - 22 ksi Minimum Compressive Strength
  - Issues
    - Used Troughs in Lieu of Buckets
    - Material Yield: ~1 C.Y. short
    - Required Vertical Cold Joint
  - Time: 2 Days
  - Cost: $400 / CF

DelDOT Bridge Section

UHPC Overlay

- Overlay Application
  - 2ND Project in United States
  - UHPC Symposium, Des Moines, Iowa
- Thixotropic Mix Design
  - Stiffer than Joint Mix
  - Accommodates 10% Superelevation
  - 14 ksi Minimum Compressive Strength
- Nation's 1ST UHPC Overlay Specification
  - Input from Lafarge, Iowa DOT, Iowa State University, & FHWA
- FHWA AID Demonstration Grant
  - Awarded $257,950
  - 2-Year Inspection/Monitoring Plan



UHPC Joint Mix (Courtesy of FHWA-HRT-17-096)

UHPC Overlay Mix (Courtesy of FHWA-HRT-17-096)

DelDOT Bridge Section

UHPC Overlay - Trial

- Contractor Performed Test Pour
  - Performed July 20, 2017
  - Representatives from FHWA & DelDOT in Attendance
  - 20’ wide x 10’ long x 1½” thick segment
  - Applied Using Vibratory Screed

DelDOT
Bridge Section

UHPC Overlay

- Surface Preparation
  - UHPC Joints
    - 14 ksi Minimum Compressive Strength
    - Surface Grind
  - Tops of Beams Tined
  - Formwork & Screed Guide Assembled
  - SSD Condition using Hoses

DelDOT Bridge Section

UHPC Overlay

- Overlay Pour
  - Thickness: 1” to 3¼”
  - 4.4% Superelevation
  - Poured In Two Stages
  - Installation Time:
    - 2 Days
    - 2 Hours per Side
  - Cost: $350 / CF
- Major Challenges
  - Material Stiffness
  - Workability
  - Shrinkage Cracks
  - Accommodating Profile

DelDOT Bridge Section

WARNING!!!

THE FOLLOWING IMAGES MAY BE DISTRUBING TO SOME VIEWERS. VIEWER DISCRETION IS STRONGLY ADVISED.

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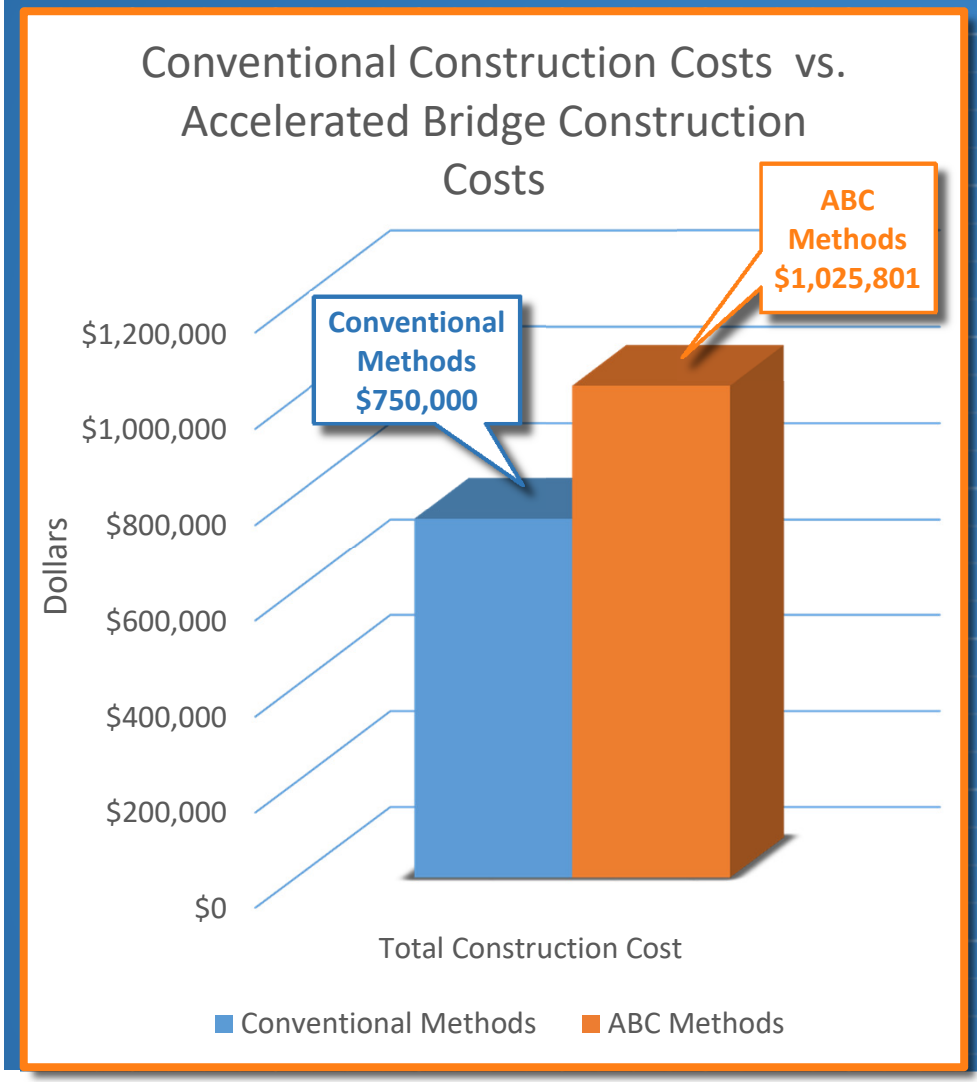
BRIDGE SECTION

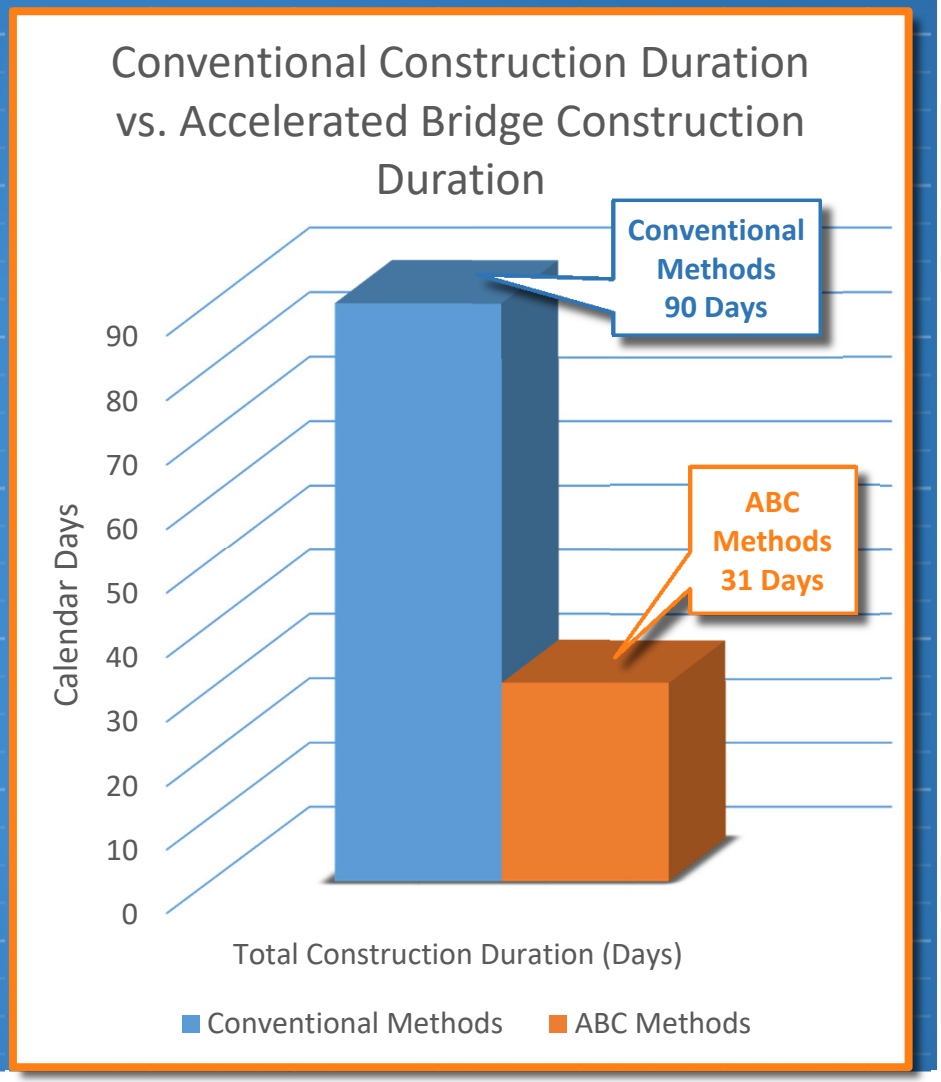
UHPC Overlay Patching & Grinding

- Patching
  - Attempted on first section of Pour
  - ¼" to ½" Depth
  - Performed 2ND Day of Pour
- Grinding
  - 2-3 Passes
  - ⅛" to ¼" Removed
  - Removed Surface Cracks
  - Exposed Fibers

DelDOT Bridge Section

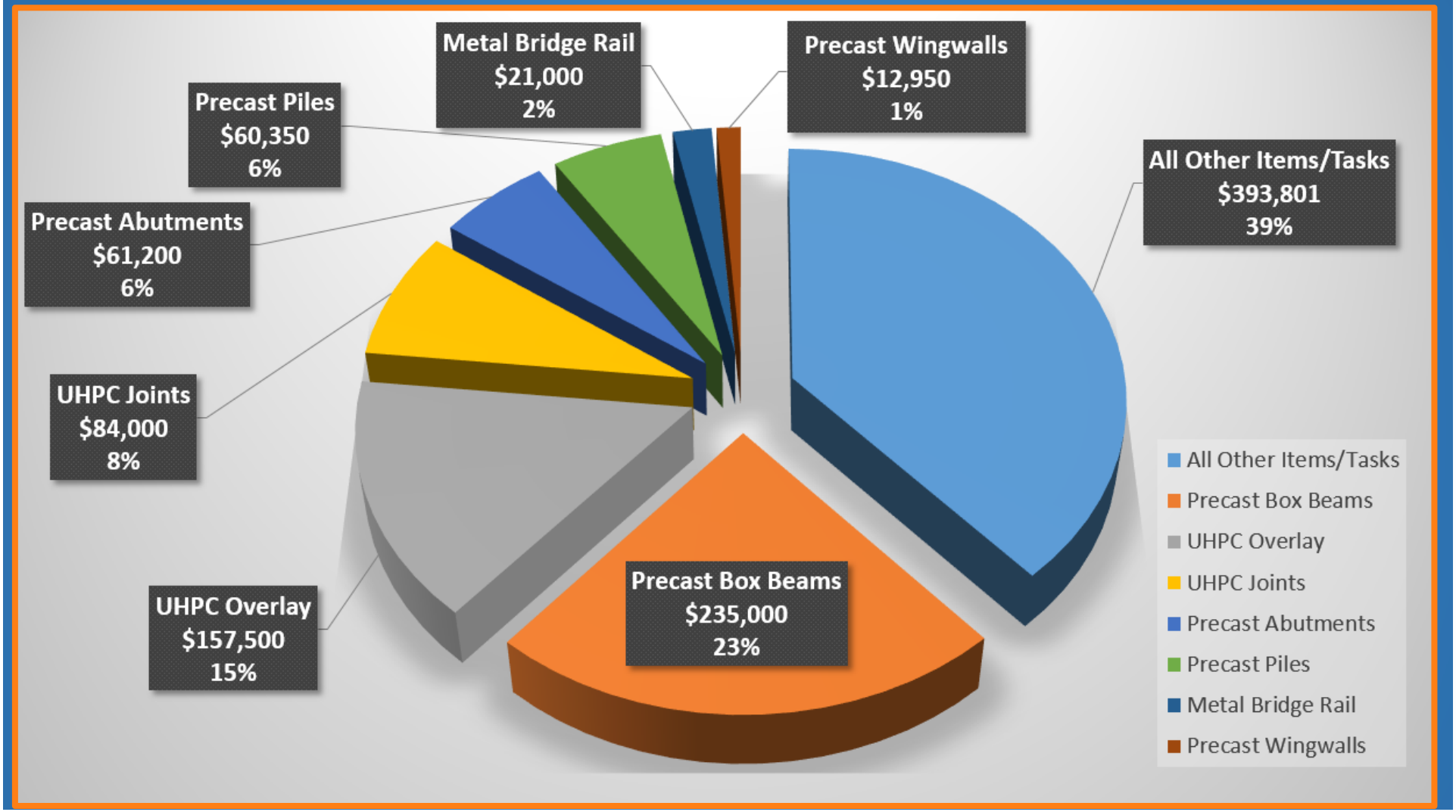
Cost & Timing Comparison





DelDOT Bridge Section

Cost Breakdown



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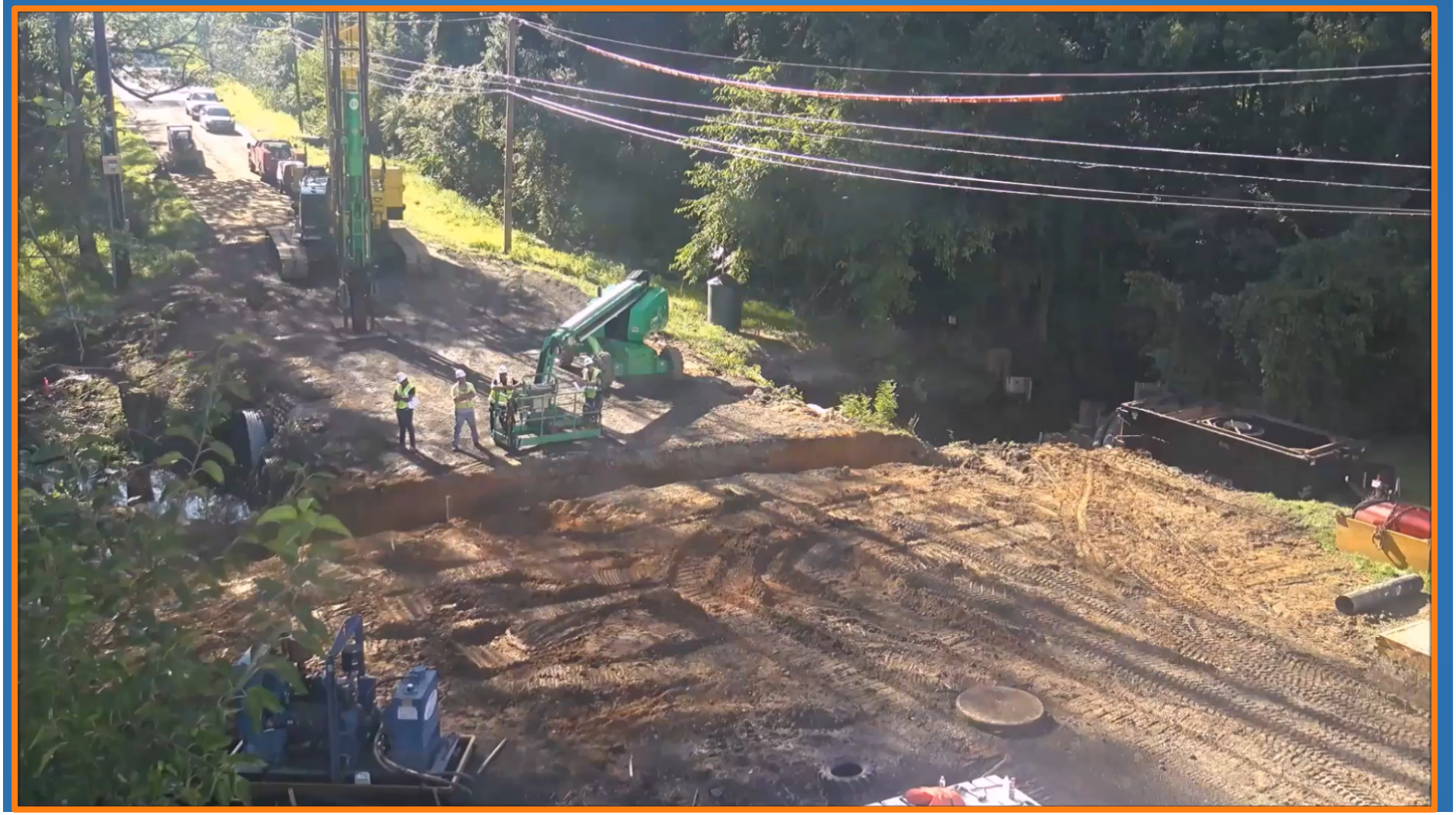
Bridge Section

BR 1-438 Time Lapse Video



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Bridge Section

Lessons Learned

- Communication
  - Precaster & Designer
  - Contractor & Department
- Precast Elements
  - Level of detail
  - Connections & Tolerances
- UHPC Joint
  - Care with formwork
  - Pressure head system
- UHPC Overlay
  - Material/Consistency Assessment
  - Future Applications
    - Rehabilitations and High Volume Roads

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QUESTIONS?

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BRIDGE SECTION