JANSSEN & SPAANS ENGINEERING, INC.

Forming the Future Since 1976

Precast/Post-Tensioned Sub-Structure Presentation

98th Road School, 2012
PRECAST CONCRETE BRIDGE SUBSTRUCTURE COMPONENTS

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PRECAST SUBSTRUCTURE COMPONENTS

➢ ADVANTAGES
  • SCHEDULE – INCREASES CONSTRUCTION SPEED
  • PLANT FABRICATION vs. CAST-IN-PLACE
    LABOR – TOLERANCES - CONTROL

➢ DISADVANTAGES
  • TYPICALLY MORE MATERIAL (CONCRETE/REBAR)
  • TRANSPORTATION COSTS & CONSTRAINTS

➢ WHEN IT BECOMES EFFECTIVE
  • REPETITIVE SUBSTRUCTURE UNITS
  • TIME SENSITIVE PROJECT
SPECIFIC PROJECT EXAMPLES

- TWO SPECIFIC EXAMPLES
  - INDIANA TOLL ROAD – GARY TREATMENT PLANT BRIDGE (ITR-GTP)
  - ROUTE 3 OVER PASSAIC RIVER
EXAMPLE PROJECT 1: ITR-GTP BRIDGE

EXAMPLE PROJECT 2: ROUTE 3 OVER PASSAIC RIVER
GENERAL STRUCTURAL DETAILS

- BRIDGE LENGTH = 2565’ (40 SPANS, EB/WB TWIN STRUCTURES)
- VERY REPETITIVE SUBSTRUCTURE
- PROJECT SCOPING REQUIREMENTS
  - REHABILITATE EXPOSED SUBSTRUCTURE TO LAST 75 YEARS.
  - WIDEN SUPERSTRUCTURE FROM 2x2 LANE CONFIGURATION TO A 3x3 LANE CONFIGURATION.
WHAT LED TO PRECAST?

- ALTERNATIVE 1 - PATCHING AND REHABILITION OF SUBSTRUCTURE
ALTERNATIVE 1 – PATCH WORK

 COULD NOT PATCH EFFECTIVELY UNDER TRAFFIC MAINTENANCE

 PATCH WORK WAS TOO EXTENSIVE – SCHEDULE
WHAT LED TO PRECAST?

- ALTERNATIVE 1 - PATCHING AND REHABILITATION OF SUBSTRUCTURE

  TIME  |  COSTS

- ALTERNATIVE 2 - COMPLETE REPLACEMENT / CAST-IN-PLACE
ALTERNATIVE 2 – COMPLETE REPLACEMENT / CAST-IN-PLACE

OPTION 2

CURE 2

CURE 1

FALSEWORK
WHAT LED TO PRECAST?

- ALTERNATIVE 1 - PATCHING AND REHABILITATION OF SUBSTRUCTURE
  - TIME ➔ COSTS

- ALTERNATIVE 2 - COMPLETE REPLACEMENT / CAST-IN-PLACE
  - TIME ➔ COSTS

- ALTERNATIVE 3 - PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMN
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS

- 4 OPTIONS CONSIDERED
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS

- OPTION 1 – MECHANICAL COUPLERS

TIGHT CLEARANCES & CONSTRUCTIBILITY CONCERNS
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS

- OPTION 2 - VOIDED REGION (LARGE)

CONCERNED WITH INTERACTION BETWEEN PRECAST & CAST-IN-PLACE CONCRETE

CAST VOIDED REGION AFTER PRECAST CAP IS SET
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS

- OPTION 3 - HIGH STRENGTH PT BARS (STRESSED &/OR NOT STRESSED)
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS
VICTORY BRIDGE (FDOT)

CAP PLACEMENT NOTES
1. USE A TEMPLATE TO LOCATE THE P.T. BARS IN THE COLUMNS. THE BARS CAN BE PLACED 2" OFF THEIR THEORETICAL POSITION.
2. PLACE PLASTIC SHIMS ON TOP OF THE COLUMN AT THE LOCATION INDICATED. MAKE SURE THE SHIM IS HORIZONTAL.
3. PLACE THE CAP OVER THE P.T. BARS AND PROTRUDING DUCTS AND SIT ON TOP OF THE SHIMS.
4. SEAL AROUND THE EDGE OF THE JOINT BETWEEN CAP AND COLUMN AND POUR THE JOINT BETWEEN TOP OF COLUMN AND BOTTOM OF CAP USING SURE CRIP HIGH PERFORMANCE CEMENT OR EQUIVALENT.
5. AFTER CURING OF CEMENT, STRESS THE P.T. BARS.
ALTERNATIVE 3 – PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMNS

- OPTION 4 – BUNDLED MILD REINFORCEMENT

![Diagram showing bent cap and columns with bundled reinforcement.]
OPTION 4 – BUNDLED MILD REINFORCEMENT

PROPERLY SEAL AROUND THE EDGES OF THE JOINT BETWEEN THE CAP AND COLUMN.

USE SAME TEMPLATE TO LOCATE THE REINFORCING BARS IN THE COLUMN AND PRECAST CAP.

HIGH DENSITY PLASTIC SHIMS (6”x3”x2”) (KOROLATH OR EQUIVALENT) (SEE NOTE 2.)
TYPICAL LIFTING SKETCH
CONSTRUCTION
**Time & Material Savings**

- **Time Savings**
  - **Cast-In-Place**
    Sequential Construction
    1 Team of 5 Carpenters can construct 3 Caps in 8 days.
  - **Precast**
    Simultaneous Construction
    1 Team of 5 Carpenters can install up to 12 Caps in 1 day.

- **Material**
  - Precast requires more material & added transportation costs
  - In this project, rebar installation was installed in a precast fabrication shop which was more cost efficient

- **Time + Material Savings = $300/yd^3**
Saving Summary?

- ALTERNATIVE 1 - PATCHING AND REHABILITATION OF SUBSTRUCTURE
  
  TIME \rightarrow COSTS \rightarrow $2.5 Million Savings

- ALTERNATIVE 2 - COMPLETE REPLACEMENT / CAST-IN-PLACE
  
  TIME \rightarrow COSTS \rightarrow $450k Savings

- ALTERNATIVE 3 - PRECAST BENT CAPS WITH CAST-IN-PLACE COLUMN

TOTAL SAVINGS = $2.95 Million
Basic Design Theory

- **Precast Cap**
  - Flexural & Shear Strength
  - Utilize Strut & Tie as needed for connection

- **Cast-in-Place Column**
  - Interaction Diagram
  - Required Reinforcement Ratios
    - Use reduced concrete area specification to minimize required reinforcement
Basic Design Theory

Interaction Between Cap & Column

• Develop Rebar in Tension & Compression across interface

  Bundled Rebar requires longer development & hence more rebar, but significantly increases constructability

• Take advantage of added compression for flexural strength
Constructability Checks
Yard, Storage, Transportation & Erection

- Easy compared to industry standard
  - Common to transport
  - Impact = 30%  Tilt = 8%
Constructability Checks
Yard, Storage, Transportation & Erection

- Lifting Strand Design
  - Splay Strands as much as possible (increases concrete consolidation and bond)
  - Use of a Safety of Factor
    - Minimal Redundancy. S.F. > 4.0 (PCI & JSE Standards)
  - PCI min. embedment = 24”. Project min. embedment = 48”
  - Strand surface needs to be completely free of contaminants, oil, grease &/or rust which could reduce the bond
  - Do not rely on strengths per strand in excess of 8kips

PCI DESIGN HANDBOOK _ CHAPTER 5, PRODUCT HANDLING AND ERECTION
BRACING
Beam Stresses

- Check State Specific Requirements
- Mildly Reinforced = Hold to around $4.5 \times \sqrt{f'c}$
- Prestressed (check project specific requirement)
  - Longitudinal Stresses around $3 \times \sqrt{f'c}$
  - Principal Shear Stresses around $2 \times \sqrt{f'c}$
Design Recommendations

- Use a minimum 2” grout pad with adjustable high density plastic shims at interface
- Use a template to match reinforcement. Use an oversized PT Duct where possible
- Bundle Reinforcement when possible
- Place Grout Inlet at base and outlets at top
- Don’t push limits on Lifting Strands

EXAMPLE PROJECT 2
PRECAST CONCRETE BRIDGE SUBSTRUCTURE

Route 3 over The Passaic River, NJ
EXAMPLE PROJECT 1: ITR-GTP BRIDGE

EXAMPLE PROJECT 2: ROUTE 3 OVER PASSAIC RIVER
Precast Concrete Bridge Substructure
Route 3 over The Passaic River, NJ
Construction

VIEW LOOKING EAST-NORTHEAST
PROJECT INFORMATION

• Existing Bridge Size:
  • 98 feet wide x 720 feet long (6 lanes)
• New Bridge Size:
  • 225 feet wide x 750 feet long (12 lanes)
  • Cast-in-Place Concrete Substructure
  • 6 Spans, 5 Piers, 45 Columns
• Location: Clifton City, NJ
• Scheduled Completion Date: 04/2015
VALUE ENGINEERING DESIGN

• Precast & Post-Tensioned Concrete
• Value Engineering Scope of Services
  • Match existing Configuration & Capacity
  • Redesign Cap as Post-Tensioned Precast
  • Design Piers and Columns as Precast
• Detailing
  • Precast Reinforcing Steel Shop Drawings
  • Post-Tensioning Shop Drawings
  • Cast-in-Place Reinforcing Steel Shop Drawings
• Construction Administration
ERECTION SEQUENCE

STEP 14:
- Install PT bar couplers and PT bar pier cap extensions.
- Grout PT pockets.
- Place precast pier caps on leveling shims.
- Grout joint between precast column and precast pier cap.
- Install PT bearing plates and anchor nuts.
- Stress vertical PT bars (25k EA).
- Grout rebar couplers in cap and cap PT ducts and pockets.

STEP 15:
- Pour cast-in-place closure pours in pier caps.
- After a min. 7 days and closure pour concrete reaches 100% design capacity min., the PT can be stressed.
ERECTION SEQUENCE

STEP 17:
- Pour cast-in-place closure pours in pier caps.
- After a min. 7 days and closure pour concrete reaches 100% design capacity min.,
  the.pt can be stressed.

STEP 18:
- Pour remaining pier cap with HPC concrete.
TYPICAL DESIGN DETAIL

ORIGININAL

VALUE

ENGINEERING

TYPICAL PIER CAP SECTION
(TYP. FOR PIERS 1 & 3)

TYPICAL PIER CAP SECTION
(TYP. FOR PIERS 1, 2, 3 & 5)

SCALE: 3/4" = 1'-0"
TYPICAL DESIGN DETAIL
ORIGININAL

TYPICAL PIER CAP SECTION
(TYP. FOR PIER 4)
SCALE: 3/4" = 1'-0"

TYPICAL PIER CAP SECTION
(TYP. FOR PIER 4)
SCALE: 3/4" = 1'-0"
TYPICAL SHAFT – PIER – COLUMN
DETAILS

#22 SPIRAL WITH 3" PITCH AND ADDITION
(SEE NOTE 5)

15' 0"

7' 6" DIA. SOCKET

TIP ELEVATION

LOAD CELL
(SEE NOTE 7)

PIER SHAFT ELEVATION
SCALE: 1/4" 1'-0"
TYPICAL SHAFT – PIER – COLUMN DETAILS

- 9-#32 BARS E.F.
- #22 SPIRAL WITH 3" PITCH
- 9'-0" @ PIER 1, 11'-0" @ PIER 2 & 5, & 13'-0" @ PIER 3 & 4
- ARCHITECTURAL TREATMENT (PIERS 2 THRU 5)
- #22 HOOPS SPA. @ 3" IS EACH END
- TOP OF PERMANENT STEEL CASING (SEE NOTE 2)
- 8'-0" DIA. SHAFT
- 56-#36 MAIN BARS (SEE NOTE 5)
CONSTRUCTION
TOP OF PRECAST RING
LOOKING ACROSS THE PASSAIC RIVER
SETTING OF THE SECOND CAP
ERECITION AT NIGHT
ERECITION OF THE NORTH SIDE
VIEW OF PRECAST SUBSTRUCTURE & STEEL GIRDERS
VIEW OF PRECAST SUBSTRUCTURE & STEEL GIRDERS
VIEW LOOKING WEST-SOUTHWEST
ADVANTAGES
REDUCED CONSTRUCTION SCHEDULE

• Sub-Structure Construction Schedule
  • Original Schedule – 20 Months

• Negotiated Revised Schedule (3 Pieces/Day)
  • 17 Months

• Actually Erecting Ave. 4.5 Pieces per Day
  • 11 Months (Potential 8 Months Sooner)
ADVANTAGES
REDUCED CONSTRUCTION COST

• Sub-Structure Construction Cost Savings
  • 15 Percent (Negotiated Savings)
  • $400,000.00 (Four Hundred Thousand Dollars)

• Excluded Value Engineering Design Fees
  • 20 Percent
  • $500,000.00 (Five Hundred Thousand Dollars)

• Initially Designed as Precast/Competitively Bid
  • 25 Percent or More
  • $700,000.00 (Seven Hundred Thousand Dollars)
Design Recommendations

- Review all options in preliminary design phase
  - Cast-In-Place
  - Cast-In-Place with Post-Tensioning
  - Precast
  - Precast with Post-Tensioning
• Evaluate Working Conditions & Effects on Construction Costs
• Detail sections with All Reinforcing Shown
  • Reinforcing is thicker than 5 mm lead
• Detail out Grout and Vent tubes with Reinforcing
• Design & Detail with Construction Tolerances in Mind
• Oversize Grout Ducts
Design Recommendations Cont.

- Oversize Caissons to Allow Construction Tolerances
- Oversize Couplers to Improve Constructability
- Detail Reinforcing to Scale & @ Required Bend Radii
- Limit Congestion of Reinforcing Steel
Questions?