Santa Fe/C470 Flyover

Introduction: Mansour Mike Mohseni, PE, CDOT Staff Bridge
CDOT Precast Curved Tub History: Ken Saindon, PE, SE, ATKINS
C470 Flyover Design: Clint Krajnik, PE, SE, Tsiouvaras Simmons Holderness
First CDOT Curved Precast Tub Bridge (38\textsuperscript{th} & Fox) constructed in 1992

- Used on 9 total projects (1 more ready to construct)
- 25 separate structural units
- Alternative Bridge Design Spec.
Introduction: C470 Flyover Bridge

- Alleviated Traffic Congestion on Santa Fe Blvd SB to C470 EB
- 1750 ft long composed of two 6-span units (165 ft typ. span)
- Alignment on 888ft Radius
- Pier Columns up to 67ft tall
- Precast Pier Caps, Precast Curved Tubs, and Precast Partial Depth Deck Panels
Background of CDOT Precast Curved Tub Girders

Ken Saindon, PE, SE, ATKINS
- 20 years bridge design experience
- Designer of Curved Precast Tubs on Ramp H

C470 Flyover- Precast Pier Cap & Curved Tub Design

Clint Krajnik, PE, SE, Tsiouvaras Simmons Holderness
- 15 years bridge design experience
- Engineer-of-Record for C470 Flyover
Projects requiring box girders

## Context Within Designer’s Toolkit

<table>
<thead>
<tr>
<th></th>
<th>CIP Concrete Box</th>
<th>Steel Box</th>
<th>Segmental Concrete Box</th>
<th>Precast Concrete Tub/Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falsework Demands</td>
<td>High</td>
<td>Low to None</td>
<td>Low to None</td>
<td>Low to medium</td>
</tr>
<tr>
<td>Span range</td>
<td>250’ +/-</td>
<td>600’ +</td>
<td>600’ +</td>
<td>up to 300’</td>
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<tr>
<td>Redecking effort</td>
<td>Difficult</td>
<td>Easy</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Construction tolerances</td>
<td>Generous</td>
<td>* Unforgiving</td>
<td>Unforgiving</td>
<td>Generous</td>
</tr>
<tr>
<td>Relative Cost</td>
<td>Low</td>
<td>* High</td>
<td>High</td>
<td>Medium</td>
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* based on historical experience in Colorado
Previous Projects – 38\textsuperscript{th}/Fox (1992)
Previous Projects – I-25 Trinidad (2010)
C-470/Santa Fe (2011)
Alternative Design Specification

- Enables a market-based choice for Contractors
- Design requirements
  - Structure types allowed
  - Aesthetic equivalency to default
  - Functional & durability equivalency to default
- Submittal requirements
- Construction QA/QC requirements
C470 Flyover Topics

- Precast Pier Caps
- Tub Girder Lids Cast in Precast Yard
- Permanent Monostrands in Segments
- Precast Partial Depth Deck Panels
- Project Summary
Topic 1. Precast Pier Caps
Goals of Precasting Pier Caps

- Eliminate falsework at the piers
- Reduce construction operations above traffic
- Reduce time required to construct the caps
- Save construction dollars
- Provide a quality product
Precast Pier Caps

TYPICAL SECTION - PIERS WITH CLOSURE POURS
Precast Pier Cap Details
Precast Pier Cap Connection

Temporary Support

Column

#11 Bar in 5"Ø duct (6 total)

1 3/8"Ø Threaded rod in 5"Ø duct with tie down plate (4 total)

Pier Cap and Closure Pour

2

Closure Pour

6'-0"

2'-6"

3'-7"

3'-7"

Backer rod all around

Column

3" (Typ.)

#11 Bar (6 total)

1 3/8"Ø Threaded rod (4 total)

Pier

Grout

4 Spa. Ø 9½" = 3'-2"

5"

4 Spa. Ø 9½" = 3'-2"

5"
Pier Caps Cast in Box Beam Bed
Sleeves Oversized – Locations Critical
Sloped Ends Left Off In Bed
Column with Projected Bars/Rods
Slide Cap over Bars Rods
Precast Pier Cap
Designed to Support Girder Weight
CIP Pier Cap Stem
Precast Pier Cap Benefits

- Improved safety
- Improved quality
- Reduced construction duration
  - Erected all 13 precast caps in 3 nights
  - Grouted all precast caps within 2 days and 2 nights
  - Total reduction of 20 nights of traffic control [25 nights vs. 5 nights]
- Reduced construction cost
Topic 2. Lid Slabs Cast at Precast Yard

Standard Curved U Girder Section

Section with Precast Lid Slab
Girder Stability During Deck Pour
Curved Girder Torsion

Undeflected Shape  Deflected Shape

C-470/Santa Fe Flyover
Traditional Stability Solutions

External Stability

Steel Bracing

Internal Stability

Grouted Connection

Precast Panel
Precast Lid Slabs

- **Construction Sequence**
  - Girder Cast in Bed without Lid
  - Picked and Set on Donnage
  - Cast Lid Slab Prior to Shipping
  - Field Cast Small Portion of Lids

- **Simple & Efficient**
  - Constant Thickness Lid Placed Directly on Tub Girders
  - Lid Slab used as SIP Form
Precast Lid Slabs

- Precast Yard vs. Field Construction
- Controlled Environment
- Ground Level Construction
- Easy to Ensure Quality
- Reduces Traffic Disruption
Precast Lid Slabs

- **Design Considerations**
  - Adds Shipping Weight to Girder
  - Limits Length of Girder Segments
  - Girder Haunch Becomes Full Width
  - Controlling Haunch Depth is Critical
Precast Lid Slab Benefits

- Improved quality and constructability
- Reduced field construction time
  - Reduced Field Work and Traffic Disruptions
  - Saved 12 Days of Panel Erection
  - Eliminated 12 Days of Grouting Panels
  - Avoided 16 Nights of Traffic Disruption
- Saved construction costs
Topic 3. Permanent Monostrands

- Permanently Encapsulated Single Strand Tendons
- Alternative to Multi-Strand Anchorages
- Used for Segment Shipping, Handling, and Erection Stresses
- Used for Final Stress Control
- Not considered for Ultimate Moment per CDOT
Permanent Monostrand Advantages

- Easy to Install
- No ducts or grouting (unbonded)
- Precaster can self-perform stressing operation
- Eliminates PT hardware and Anchorage Blisters
- Efficient: Low Friction Losses & Anchor Set
- Saves Cost
Topic 4. Partial Depth Precast Deck Panels

- Panels serve as deck form and bottom of deck
- Pretensioned Tranversely
- Tight fit at tranverse joints
- Bear on High Density Styrofoam
Partial Depth Precast Deck Panels

Advantages

- Don’t have to remove forms
- Less Field Rebar
- Less concrete during deck pour
- Efficient Use of Materials
- Inspectability Improved
- Reduces Tripping Hazard
Partial Depth Precast Deck Panels

- **Design Considerations**
  - Simple Span for Deck Weight
  - Continuous/Composite for Live Load/SDL
  - Only recommended for decks with a wearing surface
  - Strands extended further for curved tub girders
Lessons Learned

- Plans require a high level of detail to ensure fit up
- Close coordination between the designers, contractor and fabricator is essential
- Test sections were helpful
Project Summary

- Project completed in 18 months, 5 months ahead of schedule
- Reduced Lane Closures
- No Safety Incidents
- Cost Effective - $95 per sq ft (including design)

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<th>Winning Bid</th>
<th>Continuous Spliced Precast Tubs</th>
<th>5.44 Million</th>
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<tbody>
<tr>
<td>Engineer Estimate</td>
<td>Simple-Made-Continuous Precast Tubs</td>
<td>6.32 Million</td>
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<tr>
<td>Second Bidder</td>
<td>Steel Plate I-girders</td>
<td>7.72 Million</td>
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Curved Precast Concrete Bridges State-of-the-Art Report (CB-01-12)
Q & A

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