When is balanced cantilever bridge construction a more feasible option?

Design and Construction of the I-95/I-295 and I-4/Lee Roy Selmon Flyovers

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Learning Objectives
Balanced Cantilever Construction
I-4/Lee Roy Selmon Connector – Ramp C
I-95/I-295 North Interchange – Ramp SE
Questions
Learning Objectives

- Basic Overview of Balanced Cantilever Construction Method
- Design Considerations in Determining Segment and Span Layout
- Structural Analysis of a Precast Segmental Balanced Cantilever Bridge
- Detailing Issues and Protection Measures for Post-Tensioning
Balanced Cantilever Construction

- The “balanced” cantilever construction method involves cantilevering segments outward from a fixed point on alternate sides.

- Successive balanced cantilever units are then joined together using cast-in-place closure pours to form a continuous unit.

- End spans are typically erected on falsework and joined to cantilevered units using closure pours.
Advantages of BC Construction

- Construction over traffic
- Short lead time compared to steel
- Use local labor and materials
Project Overview

- Ramp C Description
- Balanced Cantilever Construction Sequence
- Unique Features
Project Location and Importance
- Bid Alternative 1: Steel Box Girders
- Bid Alternative 2: Segmental Girders
- Bid Alternative 3: Steel Girders & Bulb-T Beams
- Bid Alternative 4: Segmental Girders & Bulb-T Beams
<table>
<thead>
<tr>
<th>Balanced Cantilever Construction</th>
<th>940 ft (286 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>45’-3” (13.8 m)</td>
</tr>
<tr>
<td>Width</td>
<td>6</td>
</tr>
<tr>
<td>Spans</td>
<td>102</td>
</tr>
<tr>
<td>Precast Segments</td>
<td>180 ft (54.9 m)</td>
</tr>
<tr>
<td>Largest Span</td>
<td>597 ft (182 m)</td>
</tr>
<tr>
<td>Radius</td>
<td></td>
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<tr>
<td>Segment Casting Ready to Begin</td>
<td></td>
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</table>
Typical Section

45'-3"

6'  12'  12'  12'

10" Slab

9' 0"

1'-3" Web

9" Slab
Pier Segment

- 9’-0” Depth
- Span-to-Depth Ratio = 20
- Split Pier Segments
- Temporary PT Bars Used to Join Pier Segments
36” Drilled Shafts
1 Typical Footing Size
Special Foundation at Pier C4
Temporary Towers Supported by the Footing
Construction Sequence
Construction Sequence

- Internal Cantilever Tendon Anchorage
- Temporary Support Tower
Construction Sequence

- Temporary Support Tower
- Internal Cantilever Tendon Anchorage
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence
Construction Sequence - Closure

Internal Cantilever Tendons
Construction Sequence - Closure

End Span Segments

Bottom Continuity and External Draped Tendons
Construction Sequence - Closure

End Span Segments on Falsework
Construction Sequence - Closure

External Draped Tendons

Bottom Continuity Tendons
Construction Sequence - Bridge
Construction Sequence - Bridge
Construction Sequence - Bridge
Construction Sequence - Bridge
Construction Sequence - Bridge
Construction Sequence - Bridge
Segment Loader Will Be Used For Erection of Segments
Balanced Cantilever Construction

Segment Loader Will Be Used For Erection of Segments
Future High-Speed Rail Corridor

Pier C4

Ramp C
Pier C4 Segment

- Skewed Pier Needed to Accommodate Rail
- 4’ Max Column Width
- Eliminate Large CIP Pier Segment

![Diagram of Pier C4 Segment]

- **Precast Pier Segment**
- **Precast Typical Segment**
- **Cast-in-Place**
- **Diaphragm/Closure**
Pier C4 Segment

- Double Column Pier with Offset Bearings
- Investigate Torsion in the Pier Segment
Pier C4 Segment

- Force Vectors in the Top Slab
I-95/I-295 North Interchange

Project Overview

- Design Considerations
  - Span Configuration
  - Segment Dimensions
  - Erection Method
- Unique Features
- Florida DOT Requirements for Segmental Bridges
Project Location and Importance
Existing Interchange
Phasing
Phasing
Structure Types Considered

Steel Box Girders

Segmental Concrete Girders
Ramp SE Statistics

- Balanced Cantilever Construction
- Length: 2,256 ft (688 m)
- Width: 49’-3” (15 m)
- Spans: 10
- Precast Segments: 234
- Largest Span: 274 ft (83.5 m)
- Radius: 1250 ft (381 m)
- Completed is August 2010
Span Arrangement
Span Arrangement
Span Arrangement
Variable Segment Depth

- Segment Depth Varies from 9’-6” to 12’-0”
- Variable over Six Segments (12’-0”)
  - Span to Depth Ratio = 23
- Constant Depth at Piers 2 and 10 (9’-6”)
  - Span-to-Depth Ratio = 24
Balanced Cantilever Construction

Ground Based Crane Erection Scheme
Foundation

- 30” Square Prestressed Piles
- 10 Piers With only 2 Footing Sizes With Varying Pile Arrangements
- Temporary Towers Supported by the Footing
Typical Segment

- 9’-6” Depth
- Temporary PT Erection
  Blisters Near Top Slab
- Can Reuse the Erection Bars
- External PT Bars Don’t Need to Be Grouted
Erection PT Bars

Mixed use of External and Internal Erection PT Bars in Bottom Slab
Erection PT Bars

Transition from External to Internal PT Bars

External PT Bar

Internal PT Bar
Pier Segment

- 12’-0” Depth
- Split Pier Segments
- Temporary PT Bars Used to Joint Pier Segments
Deviator Segment

- Full Height Deviators
- Combined with Bottom Slab Blister
- Provides Horizontal Deviation Due to Curvature
- Accommodates Future PT
<table>
<thead>
<tr>
<th>Bridge Element</th>
<th>Minimum # of Tendons</th>
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<tbody>
<tr>
<td>Midspan Closure Pour</td>
<td>Bottom Slab – 2 tendons per web</td>
</tr>
<tr>
<td></td>
<td>Top Slab – 1 tendon per web</td>
</tr>
<tr>
<td>End Span Units</td>
<td>3 tendons per web</td>
</tr>
<tr>
<td>External Draped Tendons</td>
<td>2 tendons per web</td>
</tr>
</tbody>
</table>

- **Tendon Redundancy and Protection are Vital to Long-term Durability**
  - More conservative but tendon corrosion problems have been an issue in Florida
  - Multiple Layers of Protection
Segment Duct Couplers

FDOT Vendor Drawings for Approved PT Systems

Matchcast Segment | Bulkhead Side

GTI Segment Coupler Assembly (12-0.6” )

Straight Alignment

Skewed Alignment
Segment Couplers

Top Slab Tendon Segment Couplers During Match Casting
Casting Yard (July ‘08)
Thank You