Segmental Bridge Construction

Segmental Bridges – It’s a Construction Technique with Design Implications

2010 FDOT/FTBA Construction Conference
February 23-24
Orlando, Florida
Presentation Speakers

Brian Blanchard, P.E.
Florida Department of Transportation

Enrique Espino, P.E.
Condotte America, Inc.

Jim Schneiderman, P.E.
PCL Civil Constructors, Inc.

R. Craig Finley, Jr., P.E.
Finley Engineering Group, Inc.
Agenda

- **Florida Department of Transportation’s Perspective**, Brian Blanchard, P.E., *Florida Department of Transportation*

- **Contractor’s Perspective**
  Enrique Espino, P.E., *Condotte America, Inc.*
  Jim Schneiderman, P.E., *PCL Civil Constructors*

- **Design and Construction Engineers’ Perspective**
  R. Craig Finley, Jr., P.E., *Finley Engineering Group, Inc.*

- **Future Perspective**, Enrique Espino, P.E., *Condotte America, Inc.*

- **Round Table Q & A**
Segmental Bridges – It’s a Construction Technique with Design Implications

From the Florida Department of Transportation’s Perspective

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Brian Blanchard P.E.
Chief Engineer
Florida Department of Transportation
From the Florida Department of Transportation’s Perspective

- History of Segmental Bridges in Florida
- FDOT Policies and Procedures
- Experience and Future Treads
History of Segmental Bridges in Florida

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Brian Blanchard P.E.
Chief Engineer
Florida Department of Transportation
History of Segmental Bridges in Florida
– The Early Years

- Long Key Bridge
- Channel 5
- Seven Mile
- Niles Channel


Span-by-span
Balanced Cantilever
All dates given are completion dates
History of Segmental Bridges in Florida
– The Early Years
- The Early Years (cont.)

- Span-by-span
- Balanced Cantilever

All dates given are completion dates

1985
- I-75/SR 826 (5 Bridges)
1986
- I-595/I-75 (5 Bridges)
1987
- Ft. Lauderdale Airport (4 Bridges)
1988
- I-595/I-75 (6 Bridges)
- I-595/US 441 (2 Bridges)
Long Key Bridge
First application of Precast Span-by-span Bridge Construction in the U.S.

1981
Seven-Mile Bridge
First Application of an Overhead Gantry in Florida
Ramp I Bridge
First application of Precast Balanced Cantilever Construction in Florida

1984
- Other Firsts

First Demolition of Existing Segmental Bridge in the North America.

Fort Lauderdale-Hollywood International Airport expansion required the removal of three precast segmental concrete bridges.

How did we demolish segmental concrete bridges built by the balanced-cantilever method? By reversing the way the segments were installed.
- Other Firsts
I-75/ SR 826 Ramp A - First Segmental Bridge Widening in U.S. Mainland

Crews have completed the widening of a segmental fly-over bridge in Miami-Dade County—a rare construction feat and the first job of its kind in the mainland United States.
Current Number of Segmental Bridges – 68
(3 have been removed at Ft. Lauderdale Airport)
FDOT Policies and Procedures
FDOT Policies
In Response to PT Corrosion Issues

Advanced Corrosion of Strands within Niles Channel Anchorage
FDOT Bridges w/ Grout Problems

6 Bridges at I-75 & I-595
(Voids in Tendons)

Niles Channel Bridge

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Chief Engineer
Florida Department of Transportation
FDOT Bridges w/ Grout Problems (cont.)

Mid-bay (Spans 28 and 57
2- Failed Tendons)

Skyway Approach (Failed
Tendon Pier 133 N)
New Directions for Florida Post-Tensioned Bridges
Corven Engineering, Inc.
February 15, 2002

5 Strategies for Improved Post-Tensioned Bridges in Florida
- Enhanced PT Systems
- Multiple Tendon Paths
- Fully Grouted Tendons
- Watertight Bridges
- Multi-Layered Anchor Protection
Segmental Bridge Construction

Policy Revisions

- Specify Minimum Layers of Protection
- Develop Anchorage Protection Standard Details and QPL Pour-back Materials
- Develop P.T. Redundancy Requirements
- Refine Grouting Procedures
  - Pre-approved P.T. Systems
  - Qualified Grouting Personnel/Inspectors
  - Specify Low-Point-Up Grouting
  - Specify Non-bleed QPL Bagged Grouts
  - Specify Inspection Access Points
Experience and Future Trends
Experience and Future Trends –

- Segmental top-down construction techniques are cost effective on large waterway projects where insurance and labor rates are governed by time working from barges.

- Larger projects generally make segmental construction more cost effective due to the casting yard setup cost being spread over more segmental units and when the amount of work is sufficient to overcome learning-curve inefficiencies.
Experience and Future Trends (cont.) –

- Segmental alternatives have been competitive against steel box options where the number of segmental units is sufficient (greater than 600-700 units).
- Segmental options have not been competitive on small projects when bid against simple span prestressed beam options.
Future Trends – Customized Overhead Gantries

- Allowing Cantilever Construction on Curved Ramps
- Greatly Reducing Traffic Disruptions

Example: Palmetto Section 5
Future Trends – Greater Use of Combined Steel and Concrete to Reduce Weight?

- Core Segment
- External Strut + Rib
- Precast Panel

Example: Yamakiri Viaduct (Japan)
Future Trends – National Post-Tensioning Specification

PTI is currently developing a nationwide post-tensioning specification based largely on FDOT specifications, research and past experiences.
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S.E. 17th Street Bridge
Segmental Bridges – It’s a Construction Technique with Design Implications

The Contractor’s Perspective

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- Types of Segmental Bridges and Characteristics
- Precasting Segments - *Superstructures & Substructures*
- Erecting Precast Segments - *Superstructures & Substructures*
- Cast-in-Place with Form Travelers

Enrique I. Espino, P.E.
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Types of Segmental Bridges and Characteristics

Jim Schneiderman, P.E.
PCL Civil Constructors, Inc.

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• Types of Segmental Bridge Structures
  – Precast Span by Span
  – Precast Balanced Cantilever
  – Precast Progressive Placement
  – Cast-in-Place Balanced Cantilever
  – Cast-in-Place Incremental Launching
  – Cast-in-Place & Precast Cable Stayed
Segmental Bridge Construction

• Precast Span by Span

Ernest F. Lyons Bridge – Stuart, FL
(Photo courtesy of PCL Civil Constructors, Inc.)
Segmental Bridge Construction

- Precast Balanced Cantilever

John Ringling Causeway – Sarasota, FL
(Photo courtesy of PCL Civil Constructors, Inc.)
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- Precast Progressive Placement

Linn Cove Viaduct – Blue Ridge Parkway, NC
(Photo courtesy of Figg Engineering Group)
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• Precast Progressive Placement (cont.)
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• Cast-in-Place Balanced Cantilever

Foothills Parkway Bridges – Smokey Mountains, Tennessee
(Photo Courtesy of PCL Civil Constructors, Inc.)
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Cast-in-Place Balanced Cantilever (Cont.)
Cast-in-Place Incremental Launching

- Casting Bed
- Launching Direction
- Launching Nose
Segmental Bridge Construction

• Precast & CIP Segmental Cable Stayed

Sunshine Skyway Bridge – Tampa, FL
(Photo courtesy of Figg Engineering Group)
Segmental Bridge Construction

Precast and Cast-in-Place Cable Stayed (cont.)
Contractor’s Perspective

Segmental Bridge Construction

Precasting Segments
Superstructures & Substructures

Enrique Espino, P.E.
Condotte America, Inc.

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Erecting Precast Segments Superstructures & Substructures

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- Precast Segmental Bridge Erection Techniques
  - Span by Span Erection Methods
  - Balanced Cantilever Erection Methods
  - Erection of Segmental Substructures
Segmental Bridge Construction

- Span by Span Erection Methods
  - ‘Top Down’ erection using under-slung truss and segment lifter

Ernest F. Lyons Bridge – Stuart, FL
(Photo Courtesy of PCL Civil Constructors, Inc.)
Segmental Bridge Construction

• Span by Span Erection Methods
  – Overhead Erection Truss

Seattle Sound Transit Light Rail Project – Seattle, WA
(Photograph courtesy of PCL Civil Constructors, Inc.)
Segmental Bridge Construction

-Span by Span Erection Methods
-Overhead Erection Truss

C&D Canal Bridge – Delaware (Photo courtesy of Figg Engineering Group)
Segmental Bridge Construction

• Span by Span Erection Methods
  – Erected on Falsework using conventional cranes

(Photo courtesy of Flatiron Constructors, Inc.)
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• Span by Span Erection Methods
  – Lifting of Entire Span at once

Jamestown Bridge – Rhode Island (Photo Courtesy of Figg Engineering Group)
Segmental Bridge Construction

• Typical Balanced Cantilever Erection Methods

1) Land or Barge Mounted Cranes

2) Deck-Mounted Lifting Equipment (Beam and Winch)

3) Overhead Gantry
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- Balanced Cantilever Erection Methods

Crane Erection from Ground

Crane Erection from Bridge Deck
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- Balanced Cantilever Erection Methods
  - Erection using a beam and winch

[Image: Oakland Bay Bridge - Oakland, CA (Photo courtesy of Flatiron Constructors, Inc.)]
Segmental Bridge Construction

- Balanced Cantilever Erection Methods
  - Erection using overhead Erection Truss

Otay River Bridge – San Diego, CA
(Photo courtesy of International Bridge Technologies)
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- **Segmental Substructures**
  - **Sequence of Erection:**
    - Place and Grout Segment to footing Keway
    - Erect remaining segments to a predetermined elevation (usually based on stability).
    - Perform intermediate P.T. to maintain pier stability
    - After all segments have been erected, permanent PT is performed (usually loop tendons through footing)
    - Tendons are then grouted.

- **Splash Zone Requirements:**
  - Many states do not allow precast substructure elements to be used within the splash zone. Above the Splash Zone, precast erection can begin.

Typical Precast Column Segment

Keyway in Footing to Align / Stress first Segment
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- Segmental Substructures

C&D Canal Bridge

Hoover Dam Bypass
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- Segmental Substructures

Stressing Vertical Column Tendon
• When does Precast Segmental Substructure make sense?
  – When you have a large volume production of typical pier shapes
  – When high quality concrete and geometry control of the piers is extremely important
  – When there is a long lead time for foundations that allows fabrication of pier segments concurrently with foundation work

* The major advantage of precasting substructure segments is the speed of erection, which surpasses any other conventional method of pier construction.
Segmental Bridge Construction

Scheduled Seminars:

February 17-18
Denver, Colorado

June 22-23
Orlando, Florida

For More Information, Please Go To:

http://www.asbi-assoc.org
Segmental Bridge Construction

Cast-in-Place with Form Travelers

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Design and Construction Engineer's Perspective

R. Craig Finley, Jr., P.E.
Finley Engineering Group, Inc.
Design and Construction Engineer’s Perspective

Presentation Outline

- Key Points to Understanding Segmental
- My Background & Perspective
- Importance of Project Procurement
- Engineering Roles & Responsibilities
- Special Considerations
Key Points to Understanding Segmental

Segmental bridges are based on a construction technique that has design implications.

Know how to build it before starting to design it.
Design and Construction Engineer’s Perspective

Background

- A bridge engineer, a Florida PE and FTBA member
- Involved with segmental bridges continuously since 1979
- Working in the USA and internationally
- Started in Florida on the Keys and now doing SR 826/836 Interchange
Design and Construction Engineer’s Perspective

Perspective

- As a designer and construction engineer
- Preference for contractor driven and design/build projects
- Typically involved with the bid

The best approach is not always the same for every one or every project.
Importance of Project Procurement

Three ways to do it:

• Design – Bid – Build
• Design – Build
• After the fact – Value Engineering or “Construction Modification”

Different approaches to incorporate construction methods
Design and Construction Engineer’s Perspective

Design – Bid – Build

• Generic design – many assumptions
• Code based – not construction methods or schedule
• Will be reworked by construction engineer before it can be built
• Multiple steps/approvals
Design and Construction Engineer’s Perspective

Design - Build

- Specific design – known construction method
- Better initial optimization and faster process
- More efficient – best results
- Responsibility is where it needs to be

Procurement
Design and Construction Engineer’s Perspective

Value Engineering / "Construction Modification"

- Combination approach
- Used for an advantage
- Has been very successful
- More common in tough times
Design and Construction Engineer’s Perspective

Engineering Roles & Responsibilities

• Design Engineer
  ➔ Owner Client

• Construction Engineer
  ➔ Contractor Client

• Value Engineering / Design Build
Design and Construction Engineer’s Perspective

Design Engineer

- Works for the owner
- Typical scope
  - Design
  - Drawings
  - Specifications
  - Cost estimates

*Based on an assumed schedule and means & methods*

Roles & Responsibilities
Design and Construction Engineer’s Perspective

The Design Engineer provides post-design services.

- Reviews and approves construction engineering
- Based on actual construction engineering
  - Takes time
  - Inefficient
  - Personalities involved
Design and Construction Engineer’s Perspective

**Construction Engineer**

- Works for contractor
- Typical scope
  - Integrated shop drawings
  - Construction analysis and camber
  - Temporary works / special equipment
  - Geometry control
  - Post-tensioning support
The Construction Engineer does the detailed design.

- Performs time dependent, step by step analysis
- Incorporates schedule and sequence
- Analyzes means and methods
- Uses sophisticated software and is very detailed

Roles & Responsibilities
Value Engineering and Design - Build

• In VE projects, there is overlap between the design and construction engineers.

• With Design-Build, the design and construction engineer are the same.

Roles & Responsibilities
Design and Construction Engineer’s Perspective

Special Considerations

The Construction Method Dictates Design

- Takes more engineering to Bid & Build
- Requires high level of planning and coordination
- Calls for a factory/assembly line mentality
- Is optimum in design/build
Design and Construction Engineer’s Perspective

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Design and Construction Engineer's Perspective

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Segmental Bridge Construction

*Future Perspective*

- More design-build & experienced Contractors.
- Standardization of precast segments
  - Supply like pre-stressed girders.
- Higher strength and composite materials.
- National specifications for materials and training.

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**Future Perspective**

- More sophisticated erection equipment.
- Rehab market will develop.
- 100+ year service life – durability.

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Round Table Q & A

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- **Design and Construction Engineers’ Perspective**
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