SPLICED BULB TEE BRIDGE DESIGN AND CONSTRUCTION

Presented by
Teddy Thery
Bryce Binney, P.E., S.E.
Parsons Brinckerhoff
Segmental Bridge Group
Outline

1. Definition & Development
   - Definition
   - Reasons for Use
   - Development of Spliced Girder Bridge
   - Current Practices
Definition of Spliced Girder:

Definition:

- NCHRP Report 517 “Extending Span Ranges of Precast Prestressed Concrete Girders” Defines as:

  Section 1.3.1 “…a precast prestressed concrete member fabricated in several relatively long pieces (i.e., girder segments) that are assembled into a single girder for the final bridge structure. Post-tensioning is generally used to reinforce the connection between girder segments.”

Reasons for Use:

- Increasing span lengths
- Improving safety by eliminating shoulder piers or interior supports (beginning applications)
- Economic considerations (cost savings over other materials) and other concrete alternatives
Original Applications of Spliced Girder

Post-tensioned spliced girder were adopted to splice simple span girder for the following reasons:

• No heavy lifting crane available on the project sides
• It is not possible to transport long girder.
Development in Florida in the 70’s:

Growing concern over highway safety during middle 1960’s

- 1967 AASHTO Traffic Safety Committee Report
  “...adoption and use of two-span bridges for overpasses crossing divided highways...to eliminate the bridge piers normally placed adjacent to the shoulders”
Development in Florida in the 70’s:

Spliced girder method was adopted to make span longer by indeterminate structure (continuous span).

Splicing girders using P/T and falsework

Florida used this approach on bridges in the late 1970’s:

- Chipola Nursery Bridge (Northwest Florida)
- I-75 Overpasses (Southwest Florida)
- Both used AASHTO Type IV with spans of approx. 115’
Current Application of Spliced Girder Bridge

- Original concept evolved to bulb-tees with haunches
- Intracoastal Waterway Crossings (navigational clearance)
- Spans up to 300’ can be accommodated
- Multi-span
Example of Recent Spliced Girder Projects

Mattaponi Bridge, VA

Pascagoula River Bridge, MS

Escambia Bay Bridge, FL
Outline

2. Construction Process

- Design/Construction Interdependency
- Erection Process
- Design Concept
Temporary Support During Construction

- Robust temporary structures
- Stable structure at all stages
- Avoid using PT bars coupler if possible

- Robust temporary bracing system
- Lock girder Supports against longitudinal and lateral sliding
Erection Process

End Segment
Haunch Segment
Drop-in Segment
1 Install Falsework
Falsework on Pier Footing
Falsework at Spliced Joints on temp. Foundations
2 Install Haunched Segments
Transporting Haunched Girders
Placement of Girder
Erecting Haunched Girders
2. Install Temporary Bracing
3 Place End Segments

Diagram showing a structure with a label indicating "Strongback."
3 Installing Strongbacks
③ Place End Segments
3 Strongback Detail
Place Drop-in Girders
4 Prepare for Drop-in Girders
4 Placing Drop-in Girder
⑤ Apply Post Tensioning
Design Concept

Significant Stages of Construction:

- Girders erected & supported by falsework or strongbacks
Design Concept

Significant Stages of Construction:

- C.I.P. diaphragms or splices poured, Stage 1 P/T applied
Design Concept

Significant Stages of Construction:

- Deck poured, Stage 2 P/T applied (deck compression)

- Longitudinally, bridge is fully serviceable. Deck and girders held to an allowable stress (usually 3\sqrt{f’c}).
Assumed Erection Sequence

Construction Sequence to be included in contract documents
3 Design Aspect

- Span to Depth Ratios
- Staged Construction Loading
- Post-Tensioning Layouts
Design Philosophy

- Two Stages of Post-Tensioning
- Stability
- Serviceability
- Time Dependant Analysis
- Ultimate Limit States
Span to Depth Ratios

General Guidelines:

- Simple span AASHTO prestressed girders (L/20)
- Continuous post-tensioned spliced girder (L/25 to L/28)
- Haunched pier continuous post-tensioned spliced girder (L/20 to L/25)

** See AASHTO LRFD Article 2.5.2.6.3. Agency may adhere to these requirements.
Staged Dead Loads

Example of Dead Load Staging:

- Erect girders

  +

- After P/T, removal of temp. supports**

  +

- Deck pouring

** Notice change in static scheme in this stage to a continuous unit
Staged Construction

*Forces/stresses in structure are sum of all load cases

Final analysis program should account for:
- Incremental summation of all loads
- Changes in static system throughout construction
- Time dependant creep & shrinkage, including beam/slab differential (CEB-FIP Model Code Capability Preferable)
- Temporary loads & supports
- Preferably ability to pour deck in stages

A few available software packages:
- BD2
- TANGO
- ADAPT
- Consplice (LEAP)
- MIDAS
- RM
- LARSA 4D
Post Tensioning

Typical Tendon Profile

- Parabolic profile
- Inflection points at 0.9 to 0.95 of span length
Post Tensioning

Typical Tendon Sizes

- 3 to 5 tendons per girder
- 9 to 15 strands per tendon
- Normally 50% of the tendons stressed on non-comp. structure

Double End Stressing

- For tendons with excessive lengths, dual end stressing may be required to overcome large friction loss.
Other Considerations

Miscellaneous Considerations

- Non-Linear Temperature Gradient
- Check Principle Web Stress (composite section complicates this procedure, perhaps check at non-composite & composite C.G.) If stresses are high, $3.5\sqrt{f'c}$ to $4.0\sqrt{f'c}$, consider using a thicker web.
- Geometry Control During Construction
- Deck replaceability
## Construction Geometry (1)

### Anticipated Deflections

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**Camber Notes:**

1. Deflection prior to deck pour (at end of first stage post-tensioning).
2. Deflection due to deck pour.
3. Deflection due to second stage post-tensioning, removal of temporary supports, and placement of barriers.
4. Deflection due to future creep and shrinkage.
5. Total deflection (1 + 2 + 3 + 4).
6. Total deflection after first stage post-tensioning (2 + 3 + 4).
Construction Geometry (2)

Total Build-up is the summation of the followings:
- Build-up due to vertical curve
- Minimum build-up at end of segments ~ 1 ¼”
- Build-up due to camber of beams
Deck Replaceability

Common Practice to include the deck as part of composite section in supporting SDL and Live Loads

Can the deck be replaced?
Answer: Yes

How can the deck be replaced?
It must be designed for deck replacement
Deck Replaceability

Design Strategy for Deck Replacement

- Use light weight Concrete Deck
- Use Precast Deck Panel
- Stress all tendons prior to deck placement
- Add temporary / permanent straight top tendon
- Deck and girder is a composite section for SDL & LL (no prestressing effect in the deck section)
Outline

4 Segment Detailing

- Web Thickness
- Pier Segment
- End Span Segments
Web Thickness

- PT Ducts
- Concrete Placement
- Vibratory Clearance
- Radial Stresses
Radial Stresses

- Strand Tensioning
- Grout Pressure
Post Tensioning Ducts

Oval Ducts

Round Ducts

Spall of outer concrete

Longitudinal cracking
Haunched Beams
Pier Segment Considerations

Erection Load Case

- Support self-weight during transport and erection
- Support weight of “drop-in” girders with prestressing (other loads: diaphragms, strongbacks, construction loads)

Prestressing Configuration

- Positive and negative moments during construction
- Use eccentricity vs. 1/P diagrams to satisfy both conditions
Pier Segment Considerations

Pier Segment Cross-Section
Pier Segment – Vertical Bursting

End of Beam Elevation
Pier Segment – Top Flange Bursting

Top Flange Lateral Bursting

Plan View of Top Flange
Ult. Negative Moment Capacity

Over-reinforced
(AASHTO Formulas)

Under-reinforced
(AASHTO Formulas)
Ult. Negative Moment Capacity

Local Widening of Compression Flange
End Segment Considerations

Anchorage Block

- Use web tapering to transition to typical beam cross-section

Bursting Forces

- Use local thickening of beam to accommodate anchorages
- Consider staging of P/T in bursting models
- If beam reaction is > approx. 10% of P/T force, consider in S & T
End Segment Anchorage

Older Anchorage System
End Segment Anchorage

New Anchorage System
Hardware System – FDOT 462

Anchorages – Including Inspection Ports
Hardware System – FDOT 462

Pressure Tested Ducts
Hardware System – FDOT 462
Pressure Tested Ducts Prior Concreting
Anchorages/End Block

Adjacent Span or backwall placed after bottom strands are jacked
Anchorages/End Block

Adjacent Span or backwall placed after bottom strands are jacked
Adjacent span or backwall can be placed before tensioning
End Segment Design

1st Stage Post-Tensioning

2nd Stage Post-Tensioning

- Also need to consider case at prestressing
End Segment Details
Outline

5. Grouting & Anchorage Protection

- Recent research has revealed the importance of good grouting practices
- Anchorages shall receive multiple layers or protection to avoid ingress of contaminants
- Florida DOT has implemented a stringent / robust PT and grouting spec. to enhance durability
Highlights of Florida Grouting

- Grout vents
- Grout Drain
- Grout Inlet

High End

Low End
Highlights of Florida Grouting

- Grout Material
  - Zero Bleed Water, Pre-Bagged, Pre-Approved

- Duct Material
  - Plastic Duct, Light Color
  - Sealed & Pressure Tested

- Grouting Procedure
  - Injected Solely from Extreme Low Point
  - High Points & Anchorages Inspected After Grouting
  - Secondary (Vacuum) Grouting if Needed
Anchorage Protection (FDOT Standard)

Four Levels of Protection:
- Grouted Tendon
- Permanent Grout Cap
- Epoxy Grout Pour-Back
- Encapsulating Diaphragm
Summary

Concrete Post-tensioned spliced girders bridge can provide an economical and durable alternative for medium span ranges. With increasing familiarity to owners and contractors, they will likely become a common solution.....
References

- Anon., Prestressed Concrete for Long Span Bridges, Prestressed Concrete Institute, Chicago, 1968.
- FDOT, New Directions for Florida Post-Tensioned Bridges, Volumes 1 & 4.
Thank you for your time

Any questions?