Stability of Precast/Prestressed Concrete Bridge Girders

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- President of Eriksson Technologies, Inc.
- 40-person full-service structural engineering firm
- Offices Tampa, FL & Denver, CO
- Special expertise in the precast/prestressed concrete markets:
  - Bridges & marine
  - Buildings
- Software development & automation
Stability Overview

- Girder Stability: Who is Responsible?
- Stages in the Life of a Girder
- Types of Stability
- Brief Overview of Theory
- Lifting Hardware
- Ways to Improve Stability
- Stakeholder Roles & Responsibilities
Stability: Who’s Responsible?

- Owner?
- Engineer of Record?
- Fabricator?
- Trucking Company?
- Erector?
- Contractor?
Stages in the Life of a Girder

- Release of Prestress
- Lifting Girder from Bed
- Moving Girder to Storage
- Storing Girder
- Hauling Girder
- Erection
- Erected Girder
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Lateral Stability

- Two basic cases:
  - Hanging beams
  - Supported beams

  - Lateral bending stability of beams
  - Hanging beams

  - Beams supported from below
  - Extends and updates Part 1
Lateral Stability

- Torsional stiffness of prestressed concrete beams >> steel beams
- Therefore, assume P/S beams are torsionally rigid
- Lateral *bending* stability of beams
- For P/S beams, we are mainly concerned with:
  - Statical equilibrium of the system
  - Ability of the beam to resist lateral bending
    - Cracking
    - Flexural strength
Theory of Stability

- Roll Axis
- Roll Equilibrium
- Factors of Safety
Roll Axis

- Between Lift Points
- CG Under Roll Axis
Roll Equilibrium

Deflection of Beam due to Bending About Weak Axis

Component of Weight About Weak Axis

Center of Mass of Deflected Shape of the Beam

a. End view

Lifting Loops

Center of Gravity of Cross Section at Lifting Point

Roll Axis

b. Equilibrium diagram
Factors of Safety

\[ FS = \frac{c_r}{c_a} \]

**Where:**
- \( c_r \) = resisting moment arm
- \( c_a \) = applied overturning moment arm

**Min. Factors of Safety (FS):**
- Against cracking: 1.0
- Against failure: 1.5
Factors Influencing Stability - Lifting

- Type of girder
- Girder length
- Lifting points
- Amount of prestress
- Material Properties
Factors Influencing Stability - Transport

- Type of girder
- Girder length
- Amount of prestress
- Material Properties
- Truck type, properties
- Roadway geometry
Lifting Hardware

- Strand lifters
- Commercially available lifters
- Special hardware
Strand Lifters

Pros

- Inexpensive
- Readily available
  - Typically made in-plant
- Variable sizing:
  - Variable stand dia.
  - # strands/lifter
  - # lifters/end

Cons

- Deterioration
- Fabrication tolerance
- Placement tolerance
- Load distribution to each lifter
Strand Lifters
Commercial Lifters

Pros
- Reliable
- Corrosion resistant

Cons
- Higher cost
- Somewhat limited capacity
Special Hardware

Pros
- Corrosion resistant
- High capacity
- Quick connect

Cons
- Requires coordination with designer
- Engineered system
Special Hardware
Improving Stability

- Adjust lift point location
- Raise roll axis
- Add top strands
- Brace top flange
- Increase $f'_c$
- Increase $I_{yy}$ (i.e., change beam)
Move Lift Points

- Reduces distance between roll axis and CG
- Easiest, most effective
- Need to check stresses!
Raise Roll Axis

- Raise roll axis above the top of the girder
- Requires special hardware
Add Top Strands

- Add 2 to 6 strands to top flange
- Can be pretensioned to post-tensioned
- Strands can be fully or partially stressed
- Add mid-span debonding if necessary to pretensioned strands
- Coordinate with EOR!
Add Top Strands
Add Top Strands
Add Top Strands

*MID–SPAN DEBONDING ACCESS POCKET*

Scale: 3”=1'-0"

*NOTE: TOP STRANDS WITH MID–SPAN DEBONDING TO BE CUT IN FIELD BY CONTRACTOR AFTER BEAM IS SET IN FINAL LOCATION. POCKET TO BE CLEANED AND POURED BACK WITH DECK CONCRETE PLACEMENT.*
Allowable Stresses

- Allowable tension
- Allowable compression
- What are appropriate limits?
- EOR vs. fabricator
- Impact factors
Impact Factors

- Handling in yard
  - Under fabricator’s control
  - Range: 1.00 – 1.20

- During transport
  - Dependent upon many variables
    - Higher speed
    - Variable road conditions
  - Range: 1.20 – 1.50
    - Truck
    - Barge
    - Rail
Brace Top Flange

- Bolt a transversely-oriented steel truss to top flange of girder
- Increases lateral stiffness
- Labor-intensive
- Last resort
Rigging

- Single-crane pick
- Two-crane pick

\[ F_h = \frac{W}{2 \tan(\phi)} \]
PCI Resources

- PCI Girder Stability Subcommittee
  - Glenn Myers, P.E., Chair
- *Lateral Stability Guidelines for Prestressed Concrete Girders*
- Excel Spreadsheet Tool
- Upcoming Training
- William N. Nickas, P.E.
  - Managing Director, Transportation Systems
Questions?

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