External Post-Tensioning for Full-Depth Precast Deck Panels

Prepared for 2012 Virginia Concrete Conference
Information presented herein pertains to proprietary products.
Today’s Presentation

• Full-Depth Precast Decks - Current Industry Practice

• The AccelBridge Systems - Construction / Engineering
The Search for an Ideal ABC System

SPMTs

Slide-In / Float-In

Full-Depth Precast Decks

Segmental

ABC Technologies

Foundation and Wall Elements

Rapid Embankment Construction

Structure Placement Methods

PBES
Full-Depth Precast Decks

Full depth precast deck system advantages:

- Uses standard girder shapes
- Doesn’t require special equipment
- Relatively simple technology

I-287 Cross Westchester Expressway, New York

- Value engineering
- A+B project
- Minimize field labor
- 300,000 sq ft of precast deck
Full-Depth Precast Panels: Current Practice

Shim pack to support panel
Full-Depth Precast Panels: Current Practice

- Duct Coupling
- Durability Concerns

- Extensive Duct Work
- Panel Alignment

- CIP joint field works
- Durability concerns
Full-Depth Precast Panels:

Attempts to Eliminate Deck PT Anchorage Tube Connection

- Unreliable grouted joint interfaces

**UHPC** (Ultra-High Performance Concrete)

- Very expensive
- Demanding on workmanship

No compression across deck joints = Durability Concerns
Full-Depth Precast Panels: AccelBridge

Goal Achieved:
Maintaining compression across deck joints without PT in the panels

<table>
<thead>
<tr>
<th>Simplicity</th>
<th>Durability</th>
<th>Speed</th>
<th>Cost</th>
<th>Current system</th>
</tr>
</thead>
<tbody>
<tr>
<td>No PT ducts in panels</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>400+ pcs</td>
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<tr>
<td>No grouted joints</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>20 joints</td>
</tr>
<tr>
<td>No duct couplers</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>400+ couplers</td>
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<tr>
<td>Save materials</td>
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<td>12,000 lbs PT or two girder lines</td>
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(Comparison from example bridge: 43 ft wide, 105 ft – 105 ft span)
The AccelBridge Systems

AccelBridge is a patented technology consisting of four systems:

- **Accel\textsuperscript{NP}**: Steel girders - no post-tensioning
- **Accel\textsuperscript{PB}**: Concrete girders with tensioned rods at pier
- **Accel\textsuperscript{PG}**: Concrete girders with post-tensioning in the girders
- **Accel\textsuperscript{PD}**: Concrete tub girders with external post-tensioning

*Simple construction with proven technologies.*
**Accel\textsuperscript{PG} System**

- No internal deck post-tensioning
- Deck compression is provided by PT internal to precast concrete girders (no coupling, less duct work, more efficient girder)
- System is very similar to typical post-tensioned precast girders, but with an innovative construction sequence
**Accel\textsuperscript{PG} System**

**Principles**

Dual function of girder post-tensioning:
- Longitudinal component provides deck compression
- Vertical component (deviation force) helps the girder resist load

*Very effective use of PT, saving girder materials*
• Construct substructures
• Erect girders
Leave a small gap between girders at pier
Erect all deck panels
Accel\textsuperscript{PG} System - Construction

Grout Pockets in End Panels
**Accel\textsuperscript{PG} System - Construction**

**Stress girder post-tensioning tendons**
• Grout haunch and shear connectors for all remaining panels.
• Finish diaphragms at abutments and pier
**Accel$^P_G$ System - Advantages**

**Conventional Full Depth Precast**
- 6 girder lines
- 360 duct couplers
- 18 tendons (11,340 lbs)

**AccelBridge**
- 4 girder lines
- 8 duct couplers
- 8 tendons (11,340 lbs)
Accel$^{NP}$ System

- Precast deck with steel girders
- Precompression of precast deck is provided by jacking against steel girders
- Best with NSBA simple for dead load and continuous for live load detail
- Can be used for deck replacement reusing existing girders
**Accel**<sup>NP</sup> System

**Use Jacking Frame to Apply Deck Compression**

**Jack Against End Panels**

*Precast deck panel at this end is composite to the girder*

*Precast deck panels in between is not composite to the girder at time of jacking*

*Precast deck panels at both ends of the bridge is composite to the girder*

*Precast deck panels in between is not composite to the girder at time of jacking*

- Jack and Jacking frame
- Steel girder
- Top flange splice plate

ABC Made Simple.
Accel$^{NP}$ System

Simple span for dead load, continuous for live load layout:

► **Jacking helps the girder resist load**
Accel$^{NP}$ System – Pier Connection

Top Flange Splice for Dead Load

Bottom Flange Grouted Splice for Live Load (Modified NSBA)
Accel$^NP$ System – Construction

Erect Girders

Top Flange Splices
Accel$^N_P$ System – Construction

Place Deck Panels

Space to Place Jacks
Accel\textsuperscript{NP} System – Construction

Perform Jacking Operations

Grout End Panel

Jacks
Accel$NP$ System – Construction

Place CIP Pour Backs prior to Removing Jacks
Accel<sup>NP</sup> System – Construction

- Grout all panels
- Remove Jacks and Complete Closure Pour
- Bottom Flange Grouted Splice at Pier
Alternative Jacking method

- Use jacking frame welded to steel girder
- Eliminate closure pour
Accel\textsuperscript{NP} System – Advantages

Conventional Full Depth Precast
- 22 x 4-0.6” PT (13,860 lbs)
- 440 duct couplers

AccelBridge
- No PT (maintains same deck compression)
- No duct couplers

Also applicable to deck replacement of existing bridges.
AccelPB System

- Typical precast prestressed concrete girders
- Two or more spans
- Deck compression provided by tensioning rods at pier
Force in the tensioned rods become deck compression

Eccentricity creates negative moment, helps the girder

Tensioning rods at pier
Accel\textsuperscript{PB} System - Construction

Erect girders

PT Bars Details at Piers
Accel$^{PB}$ System - Construction

Place Deck Panels
Accel\textsuperscript{PB} System - Construction

Grout End Panels
Accel\textsuperscript{PB} System - Construction

Stress PT Bars at Piers
Grout Haunch and Shear Connectors for All Remaining Panels.
Accel\textsuperscript{PB} System - Advantages

Conventional Full Depth Precast
- 18 x 4-0.6” PT Tendons (11340 lbs)
- 360 duct couplers

AccelBridge
- 12 x 1 \(\frac{3}{4}”\) dia threaded rod (1150 lbs)
- No duct couplers
- Girder strand savings
**Accel\textsuperscript{PD} System**

- Precast deck with external post-tensioning inside Precast Tub girders
- An economical alternate to segmental box girder
- Combines the best from two proven technologies:
  - Concrete segmental bridges with external post-tensioning
  - Full depth precast deck

Deck PT anchored at the end segment provide the compression force

Deviation force produced by deck PT assists the girder in resisting load

Deck PTs exit end segment and become external
**Accel\textsuperscript{PD} System**

- **Longitudinal PT force becomes deck compression**
- **Vertical PT deviation force helps the girder resist load**
- **PT is anchored on the deck end panel, which can move relatively to the girder.**
- **Post-tensioning tendon**
Accel\textsuperscript{PD} System - Construction

Erect Girders
Install PT and Place End Panels
Accel<sup>PD</sup> System - Construction

- Install All Deck Panels
- Stress PT
- Grout all pockets and haunches
**Accel$^P_D$ System - Advantages**

**Segmental**
- Expensive formwork
- Expensive erection system
- Special construction experience required

**Accel$^P_D$**
- No expensive formwork
- Conventional erection
- No special construction experience required
AccelBridge Applications

The AccelBridge Systems are extremely versatile:

- U- and I-girder shapes
- Steel and concrete girders
- New construction and deck replacements
- Single and multiple spans

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<tr>
<th></th>
<th>Spans</th>
<th>Construction</th>
<th>Girders</th>
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<tr>
<td></td>
<td>Single</td>
<td>Multi</td>
<td>New</td>
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<tr>
<td>Accel\textsuperscript{PD}</td>
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Match-Cast Joints

The match cast method, popular in segmental construction, is an ideal solution for full depth precast deck

- Simplified long-line match casting method
  - “Flat” casting
  - Maximum deck curvature only results in <2mm gap at joints
  - Segmental construction typically allows 3mm epoxy joints.

- MODOT’s very successful example of Nemo Bridge
  *(construction by Columbia Curb & Gutter)*

*Figure 1: Casting Bed (Every other 10’ section has concrete poured burlap curing mats on it and the others with green rebar and blockouts showing are waiting to be match cast.)*
Match-Cast Joints

Step 1 - Cast every other segment with bulkheads

Step 2 – Match cast the remaining segments
Engineering Topics

- Need to consider camber due to stressing the deck (after deck placement)

- Girder Stress Distribution
The deck is very thin in the vertical direction -- its stability must be ensured under such a large compression force.

Therefore:

*Checking deck stability is one of the most important tasks in the design of the AccelBridge systems.*

**Theory:**

- Gravity force provides the stabilizing force – buckling of the deck has to overcome the gravity force first
- The deck stability shall consider bridge profile geometry and construction tolerance.
Engineering Topics: Deck Stability

Potential destabilizing effects from bridge vertical profiles:

[Diagram showing forces and curvatures]

Potential destabilizing effects from construction tolerance:

[Diagram showing forces and tolerances]
Engineering Topics: **Deck Stability**

Level 1 – Point B unloads
Level 2 – Point C unloads

![Graph showing reaction and displacement at various stress levels.](image-url)
Engineering Topics: Deck Stability

Engineering Evaluation Results:
Typically, a safety factor of two against buckling can be readily achieved.

However, hold-down devices can provide additional safety margin:
The AccelBridge Advantage: *Durability*

**Typical Deck Internal PT**
- Joints and couplers are always the “weak links”
- Chloride can penetrate through joints and couplers

**AccelBridge**
- PT ducts are away from deck and are well protected (Accel\textsuperscript{PG} and Accel\textsuperscript{PD})
- No PT ducts (Accel\textsuperscript{NP} and Accel\textsuperscript{PB})

**Extremely Durable Deck System**
- Precast and cured in shop environment
- Can provide zero tension in the deck
- No weak spots (no PT, no coupler in the deck)
The AccelBridge Advantage: Deck Replacement

- All four AccelBridge systems can accommodate future deck replacement

- Future deck replacement for Accel\textsuperscript{NP}, Accel\textsuperscript{PB} and Accel\textsuperscript{PD} can follow the same sequence as for their original construction

- Future deck replacement for Accel\textsuperscript{PG} uses a jacking method similar to Accel\textsuperscript{NP}
The AccelBridge Advantage

Field Labor Minimized

No Complicated Equip.

Deck Panels Simplified

Durability Enhanced
The AccelBridge Advantage

**AccelBridge**

*Improves constructability; less field labor, less risk.*

**AccelBridge**

*Offers an extremely durable deck system.*

**AccelBridge**

*Saves money -- both upfront and over the bridge lifecycle.*

**AccelBridge = ABC Made Simple.**
Put AccelBridge to work for you.

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Information presented herein pertains to proprietary products.