Potential Solutions

Goals for Design – What are we concerned about?
- Primary Goal: Get the deck on successfully
  - Stability during deck pour
  - Girder plumbness
  - Deck thickness, cover, smoothness
- Secondary Goal
  - Design efficiency
“On skewed structures, in order to accommodate differential dead load deflections of adjacent stringers that exceed ½ inch at any intermediate crossframe location, the erection bolt holes in the crossframe members should be detailed as slotted holes. Hole dimensions shall be 1/16” wider than the nominal bolt diameter and ¾” longer than the nominal bolt diameter. Holes in the stiffeners shall be 3/16” larger than the diameter of the erection bolts. Final bolting and welding shall not be completed until after the deck concrete has been placed.”
Potential Solutions

One obvious solution – reduce or eliminate skew

- Solution 1 – Erect Girders Plumb
- Solution 2 – Erect Girders Out of Plumb (Pre-twist girders)
- Solution 3 – Stiffen Superstructure
- Solution 4 – Lean-on Bracing

Potential Solutions – Solution 1
Erect Girders Plumb

- Erect girders plumb
- Install all crossframes (welded)
- Girders rotate out of plumb during deck placement
- Girders will be permanently twisted

“Business as Usual” Solution
Potential Solutions – Solution 1
Erect Girders Plumb

Issues
- How much twist is too much?
  - Girders
  - Bearings
  - Crossframes

Potential Solutions – Solution 2
Erect Girders out of Plumb

Erect girders out of plumb (twisted) and girders rotate to plumb during deck placement.
Potential Solutions – Solution 2
Erect Girders out of Plumb

AASHTO/NSBA Guidelines for Constructability

Method for Erecting Girders Out of Plumb
Potential Solutions – Solution 2
Erect Girders out of Plumb

Issues
- Steel fit-up during erection
- Ability of erectors
- Where has it been done before? Is it really feasible?
- Steel detailing done correctly?
- Potential finger pointing (detailer, erector, designer, owner)

Potential Solutions – Solution 3
Stiffen Superstructure

- Stiffen superstructure
  - Add steel
    - Bigger flanges
    - Deeper webs
  - Add girder line(s)
  - Use shored construction
- Benefit – girder twist reduces with increased girder stiffness
Potential Solutions – Solution 3
Stiffen Superstructure

- Shored Construction

- Advantage
  - Composite for all dead and live loads

Potential Solutions – Solution 3
Stiffen Superstructure

- Disadvantages
  - Cost of temporary shoring
  - Need good foundations for shoring
  - Can’t put shoring in traffic
  - Undesirable to put shoring in waterway
  - Serious issues with redecking
### Potential Solutions – Solution 3

#### Stiffen Superstructure

**Example 1: Single span, 150’ span, 60 deg., 50 ksi**

<table>
<thead>
<tr>
<th>Differential Deflection</th>
<th>No. of Girders</th>
<th>Max. Girder Rotation</th>
<th>Total Girder Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Restrictions</td>
<td>5</td>
<td>0.99 deg.</td>
<td>276 k</td>
</tr>
<tr>
<td>1” Max.</td>
<td>5</td>
<td>0.50 deg.</td>
<td>443 k</td>
</tr>
<tr>
<td>½” Max.</td>
<td>6</td>
<td>0.38 deg.</td>
<td>670 k</td>
</tr>
</tbody>
</table>

**Example 2: Single span, 166’ span, 63 deg. Skew**

<table>
<thead>
<tr>
<th>No. of Girders</th>
<th>Max. Girder Rotation</th>
<th>Total Girder Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2.16 deg.</td>
<td>410 k</td>
</tr>
<tr>
<td>8</td>
<td>1.11 deg.</td>
<td>750 k</td>
</tr>
</tbody>
</table>
Potential Solutions – Solution 4
Lean-on Bracing

- Lean on Bracing
- What is it?

Potential Solutions – Solution 4
Lean-on Bracing
Potential Solutions – Solution 4
Lean-on Bracing

www.steelbridges.org

“Lean-on Cross Frame Bracing for Steel Girders with Skewed Supports”

Potential Solutions – Solution 4
Lean-on Bracing - Definitions

- Internal Lean on Bracing (Solution “4I”)

- External Lean on Bracing (Solution “4E”)
Potential Solutions – Solution “4I”  
Internal Lean-on Bracing

Potential Solutions – Solution “4E”  
External Lean-on Bracing
Potential Solutions – Solution “4E”
External Lean-on Bracing

- Bolted Crossframe
- Top & Bottom Angles, Single Bolt at Each End
- Bolted Crossframe

Place Deck – Middle Girders
Deflect
Potential Solutions – Solution “4E”
External Lean-on Bracing

- Remove Crossframe; Place Deck
- Install and Weld X-frames
- Remove Crossframe; Place Deck
- Install and Weld X-frames
Potential Solutions – Solution “4E”
External Lean-on Bracing

Miscellaneous Issues

- Bearings
- Deck Joints & End Crossframes
- Semi-integral bridges
Miscellaneous Issues
Bearings

Longitudinal slope issues

Cambered Beam Before Deck Placement
Miscellaneous Issues
Bearings

Beam After Deck Placement

Miscellaneous Issues
Bearings

Before Deck Placement
Miscellaneous Issues
Bearings

After Deck Placement

Miscellaneous Issues
Bearings

Diagram of bearings after deck placement.
Miscellaneous Issues
Bearings

Bearing Movement and Restraint Issues
Miscellaneous Issues
Bearings

Transverse Displacements

Lateral restraint issues

Fixed
Expansion
**Miscellaneous Issues**

**Bearings**

- Lateral Restraint
- Semi-integral Retainers

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**Miscellaneous Issues**

**Bearings**

- Lateral Restraint
- Seismic Pedestals
Miscellaneous Issues
Bearings - Summary

For Skewed / Wide Bridges, May Need to:

- Design for individual loads
- Design for permanent long. & lat. bearing rotations
- Design for additional longitudinal translation
- Design for lateral translation
- Prevent or design for lateral restraint forces
  - Bearing anchors or other restraints
  - Seismic pedestals
  - Semi-integral retainers
Miscellaneous Issues
End Crossframes

Miscellaneous Issues
End Crossframes
Miscellaneous Issues
End Crossframes

Miscellaneous Issues
Semi-integral Bridges
Miscellaneous Issues
Semi-integral Bridges

Miscellaneous Issues
Semi-integral Bridges
QUESTIONS?

E-mail questions to:
ose@dot.state.oh.us