ORB EAST END CROSSING
CABLE-STAYED BRIDGE CONSTRUCTION

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Doug VanSlambrook, Walsh Construction
Shawn Woodruff, Parsons Corporation
PROJECT OVERVIEW
PUBLIC-PRIVATE PARTNERSHIP

• Design, build, finance, operate, maintain
• 35 year term
• Availability payments
SECTION 5 TEAM ORGANIZATION

Owner/Owner’s Rep.

Permanent Structure / Construction Engineering

East End Partners

Developer

Temporary Works

Design-Builder
SHARED USE PATH - NIGHT
• Performance-based approach based on location/exposure
  • Concrete mix designs
  • Reinforcing type and cover for permanent/temporary elements
• Product selection
• Repairs
• Dissimilar metals
• Re-detailing of elements
• Developer involvement
**SCHEDULE**

- **Bridge Construction of Permanent Works Started:** August 2013

<table>
<thead>
<tr>
<th>Construction Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower Foundations (average)</td>
<td>11 Months</td>
</tr>
<tr>
<td>Towers (average)</td>
<td>19 Months</td>
</tr>
<tr>
<td>KY Backspan Superstructure</td>
<td>3 Months</td>
</tr>
<tr>
<td>IN Backspan Superstructure</td>
<td>6 Months</td>
</tr>
<tr>
<td>Pier Tables</td>
<td>2 Months</td>
</tr>
<tr>
<td>Mainspan Superstructure/Deck/Cables</td>
<td>5 Months</td>
</tr>
<tr>
<td>Overlay, Barrier, Railing, Lighting</td>
<td>3.5 Months</td>
</tr>
</tbody>
</table>

**Bridge Construction Duration: 41 Months**
TOWER CONSTRUCTION

8/1/2013

FOUNTATIONS

Precast Tubs

4.5 Months

Drilled Shafts

8 Months

Footings

5 Months

12.5 Months

Solid Tower Lifts, Lifts 1-7

Hollow Tower Lifts, Lifts 8-16

4 Months

Hollow Lifts with Anchor Boxes, Lifts 17-22

4.5 Months

TOWERS

Upper Struts

2.5 Mo.

2/29/2016
ERECTION METHODS

- **1200’ MAIN SPAN:** BALANCED CANTILEVER
- **540’ BACK SPANS:** STICK-BUILD ON FALSEWORK (KENTUCKY)

**INCREMENTAL LAUNCH (INDIANA)**
400 pages detailing:

- Structural Checks/Assumed Loading
- Survey Requirements
- Deflections
- Work Points Coordinates
- Deck Elevations
- Stay Forces
- Support Reactions
- Detailed Cycle/Stay Stressing Sequence in 60 Erection Schematics
BEST VALUE DELIVERED

• RFP COMPLETION DATE = 7/1/2017

DATE PROPOSED:
10/31/2016
OVERLAPPING ACTIVITIES = CRITICAL PATH GAINS
RESULT : OPTIMIZED CYCLES

### Cycle 3 to 8

#### BACKSPAN

<table>
<thead>
<tr>
<th>Task</th>
<th>Cycle 1</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>PRECAST PANEL INSTALLATION</td>
<td></td>
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<tr>
<td>INSTALL STAY PIPE</td>
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<tr>
<td>STUD/REBAR/PT/FORM/POUR STITCH (WITH NIGHT SHIFTS) 2.5 shifts</td>
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<tr>
<td>CONCRETE CURING 2500psi</td>
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<tr>
<td>INSTALL STAY CABLES</td>
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#### MAIN SPAN

<table>
<thead>
<tr>
<th>Task</th>
<th>Cycle 1</th>
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<tbody>
<tr>
<td>STEEL GRILLAGE ERECTION</td>
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<tr>
<td>INSTALL 6 PRECAST PANELS</td>
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<tr>
<td>INSTALL STAY PIPE</td>
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<tr>
<td>STAGE 1 STAY CABLE (25% stands 10% loads)</td>
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<tr>
<td>INSTALL REMAINING PRECAST PANELS (9)</td>
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<tr>
<td>STAGE 2A STAY CABLE (100% stands 35% loads)</td>
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<tr>
<td>STAGE 2B STAY CABLE (100% stands 100% loads)</td>
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“Ship channels are buoyed and lighted, and therefore it is a comparatively easy undertaking to learn to run them.”

- Mark Twain -

*Life on the Mississippi*
LIFE ON THE OHIO

OHIO RIVER AT MCALPINE UPPER

Universal Time (UTC)

Latest observed value: 27.53 ft at 6:00 PM EDT 14-Mar-2015. Flood Stage is 23 ft

Moderate: 30.0'

Minor: 23.0'

Action: 21.0'

Normal Pool: 12'

Flow (Kcfs)
SCHEDULE RECOVERY

MAINSPAN FALSEWORK
MAINSPAN FALSEWORK
RESULT: EARLY PANELS

MAINSPAN FALSEWORK
UNFORESEEN OBSTACLES
GUSSET PLATE A WARPED 1-3/16"
HEAT STRAIGHTENING
HEAT STRAIGHTENING
FINISHING STRONG
CLOSURE DETAILING

1. OPEN

SEGMENT 4M-14

ELEVATION

TOWER 3
(KENTUCKY)

MAIN SPAN CLOSURE
CLOSURE DETAILING

1. C TOWER 3 (KENTUCKY)

2. HOLD

3. LIFT

SEGMENT 4M-14

MAIN SPAN CLOSURE

ELEVATION
CLOSURE DETAILING

4. CLOSE

5. BOLT-UP

Segement 4M-14

Main Span Closure

© Tower 3
(Kentucky)
Figure 5, Components of a typical cable-stayed bridge

Cable-Stayed Bridge Nomenclature
Triangular load path
Cable-stay vs suspension reactions
The final state drives the construction sequence.
Construction engineering of a cable-stayed bridge is a complex undertaking, but the essence of the job can be distilled to three things:

• Get the bridge in the right place
• Get the right force in the stays
• Don’t break anything
Active vs passive geometry control
Things move often.

Things move a lot.
Parameters that go into the calculations:
- Design profile
- Design Cambers
- As-built geometry
- Long-term movements (creep, shrinkage)
- Erection sequence
- Temporary loads
- Ambient temperatures
You had one job.
Stressing equipment and construction engineering are tied together.
Monostrand stressing adds complexity
Each stay affects the others.

\[ V_1 = A_{11} F_1 + A_{21} F_2 + A_{31} F_3 \]
\[ V_2 = A_{12} F_1 + A_{22} F_2 + A_{32} F_3 \]
\[ V_3 = A_{13} F_1 + A_{23} F_2 + A_{33} F_3 \]

\[
\begin{bmatrix}
V_i
\end{bmatrix}
= 
\begin{bmatrix}
A_{ij}
\end{bmatrix}
\begin{bmatrix}
F_i
\end{bmatrix}
\]
Structural checks can be thought of as “big picture” items – those affecting the overall strength and stability, and “small picture” items affecting local member capacity.

The challenge with both of these are that the system is constantly changing.
Overturning effects are significant.
Wind induces overturning and twisting.
Code values underestimate wind.
Small picture considerations
STRUCTURAL CHECKS
Engineer’s Question:  
“How much does it weigh, and where are you putting it?”

Contractor’s Answer:  
“What’s the biggest load that I can put in the worst possible place?”
There can be a relationship between material costs and construction speed and complexity.

Which one is preferable often depends on where you are in the process.
The choice is between cambering the girders up and paying for extra steel, or restressing the stays after placement.

In general, the WVC team opted for complexity over materials.
Backspan Steel
Pier Table on shoring.
Backspan first
Main span cycle part 1
Field bolting time is minimized.
Main span cycle part 2
Precast panel placement
Main span cycle part 3
Installed from the deck, stressed in the pylon
Main span cycle part 4
OUR SOLUTIONS
Re-stress to target geometry
Main span cycle part 5
Studs are placed and stitches cast.
Yet more stressing
Overlapping cycles