Bridging the Communication Gap between Structural and Hydraulic Engineers
Why is this important?

- Bridging the Communication gap between two technical disciplines.
  - Best Designs are Iterative
  - Communication throughout Design Process
  - Prevents errors and re-work
  - Achieves a product that is cost-effective
Presentation Setup

“Rounds” of Iterative Phase I Planning
- Round 1: Project Goal
- Round 2: Site Hydraulics
- Round 3: Structural Planning
- Round 4: Capacity
- Round 5: Bridge Condition Report (BCR)
- Round 6: WIT
- Round 7: Scour Analysis | Foundation Design
- Round 8: Submittal Requirements

Point of Coordination
- Critical Design Components

Communication Pitfalls
What’s the goal of the project?
- Does the client want to widen the bridge?
- Is the bridge deficient?
- Is there Hydraulic concerns?
- Are there site constraints?

Point of Coordination
- Request from Hydraulic Engineer the design flood elevation based on the Highway Classification.
Round Two - Site Hydraulics | Hydraulic Engineer

- Existing Drainage Report
  - PBDHR, Local Drainage Studies
- Topography
- Regulatory Flood Elevations
  - FEMA maps
    - 100-yr Flood plain delineation
    - Floodway delineation
  - Flood Insurance Studies
    - Flood Profiles
    - Floodway Data Table
    - Summary of Discharges Table
- Flooding Observations
  - High Water (River Stage)
  - Overtopping Events (existing bridges)
  - Peak Streamflow
- Point of Coordination
  - Info Used for General Span Requirements
  - Info Used for Abutment Type and Location
Pitfall – Vertical Datum!

- Site specific survey in NAVD 88
- FEMA Models in NGVD 29
- FIS in NAVD 88 or in NGVD 29
- Converting from NGVD 29 to NAVD 88 ranges throughout Illinois from -0.4’ to 0.3’
Design Flood Elevation - Is there clearance over the Design Frequency elevation?

Planning – Structural Options to meet the IDOT low chord requirement

- Rehabilitation
- New Structure

Next Step
Bridge design recommendations with proposed construction cost estimate
Round Three - Structural Planning | Structural Engineer

- **Geometry Layout of Substructure**
  - Hydraulic Skew and NO structural skew
    - Structural Advantages:
      - Smaller bridge spans
      - Smaller Superstructure Depths
      - Lower Construction Cost
    - Hydraulic Disadvantage:
      - Not best solution for the hydraulics
      - Potential increase in scour
      - Potential increase in water surface elevation
Geometry Layout of Substructure

- Structural Skew and No Pier Hydraulic Skew (Still Deck Skew)
  - Structural Disadvantage:
    - Longer Spans
    - Deeper Structural Depths
    - Higher Construction Cost
  - Hydraulic Advantages:
    - No Pier Skew
    - Potentially Less Scour
Substructure Types for Hydraulic Engineers

- High Wall Abutments
  - Advantages
    - Used in tight site constraint areas
    - Allow for shorter spans
  - Disadvantages
    - Expansion Joints
    - Higher substructure element costs
    - Smaller waterway opening
Substructure Types for Hydraulic Engineers

- Integral Abutments
  - Advantages
    - Increased waterway opening
    - No expansion joints
    - Potential lower scour depths
  - Disadvantages
    - Longer Spans
    - Deeper structural depths
    - Potential higher superstructure construction cost

Point of Coordination
Bridge Geometry
Modeling Preliminary Bridge Geometry
- No increase in flood elevations
- Clearance for design storm
- Freeboard for design storm

Point of Coordination
- Feedback on Geometry
  - Slack in span
  - Low Chord/Structural Depth
Hydraulic Analysis shows “over” capacity

- Iterate back through general span and abutment location design (Round 3 and Round 4)

- Ultimately Reducing Span Length is Lower Construction Cost and Less Maintenance
Modifications to Superstructure

Preferred Superstructure Type for Stream Crossings:
- Precast Prestressed Concrete/ Cast-in-Place (CIP)
- Advantages: Low Maintenance and generally cheaper than steel
- Disadvantages: Deeper structural depths

Alternative to Concrete is Steel
- Advantages: Shallower Structural depths
- Disadvantages: Higher long term maintenance, Potentially higher initial construction cost
Round Four - Capacity | Structural Engineer

- **Modifications to Substructure**
  - Both Structural and Hydraulic Skew
    - When and Why would you have a structural and hydraulic skew?
      - Balancing span length
      - Minimize Structure depth with the design flood elevation
      - Optimize construction cost
Bridge Condition Report (BCR)

- Structural Document
  - Discuss Deficiencies of the Structure
  - Roadway Geometry
  - Hydraulic concerns
  - Concept sketches of (3) alternatives along with associated cost estimates and recommendations
### Bridge Waterway Information Table

<table>
<thead>
<tr>
<th>Route:</th>
<th>Waterway:</th>
<th>Section:</th>
<th>County:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Existing SN:</th>
<th>Proposed SN:</th>
<th>Prepared by:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Checked by:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Drainage Area =</th>
<th>square miles</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flood Event</th>
<th>Freq. Yr.</th>
<th>Discharge ft³/s</th>
<th>Waterway Opening - ft²</th>
<th>Natural H.W.E. - ft</th>
<th>Head - ft</th>
<th>Headwater Elevation – ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scour Design Check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtop Existing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtop Proposed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Calc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exist. Overtopping Elev.</th>
<th>at Sta.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Overtopping Elev.</td>
<td>at Sta.</td>
</tr>
</tbody>
</table>

**Datum:**
- All-Time H.W.E. & Date: [ ] ft
- Surveyed Normal Water Level: [ ] ft

**10-Year Velocity through Existing Structure = [ ] ft/s**

**10-Year Velocity through Proposed Structure = [ ] ft/s**

**2-Yr. Flow Rate = [ ] ft³/s**
Bridge scour, the erosion or removal of sediment due to flowing water around piers or abutments.
Round Seven – Foundation Design | Structural Engineer

- Point of coordination with Geotechnical Engineer
  - Provide Design Loads and Geometry
  - Provide Theoretical Scour Depths
  - Scour Type Reductions
    - Limestone – 100% reduction in scour depth
    - Shale and Sandstone – 90% reduction
    - Stiff to Hard Cohesive soil (Qu>1.5TSF)- 50% reduction
    - Soft to Stiff (0.5 TSF < Qu < 1.5 TSF) - 25% reduction
    - Qu < 0.5 TSF – 0% reduction
## Pile Capacity Table

### Illinois Department of Transportation

<table>
<thead>
<tr>
<th>Substructure</th>
<th>Reference Boring</th>
<th>LRFD or ASD or Seismic</th>
<th>Pile Cutoff Elev</th>
<th>Ground Surface Elev. Against Pile During Driving</th>
<th>Geotechnical Loss Type (Soil, Scour, Liquif., DD)</th>
<th>Bottom Elev. of Scour, LIQUEF., or DD</th>
<th>Top Elev. of LIQUEF. (so layers above apply DD)</th>
<th>Total Factored Substructure Load</th>
<th>Total Length of Substructure (along skew)</th>
<th>Number of Rows of Piles Per Substructure</th>
<th>Approx. Factored Loading Applied per pile at 6 ft. Cts</th>
<th>Approx. Factored Loading Applied per pile at 3 ft. Cts</th>
<th>Pile Type and Size</th>
<th>Plugged Pile Perimeter</th>
<th>Unplugged Pile Perimeter</th>
<th>Plugged Pile End Bearing Area</th>
<th>Unplugged Pile End Bearing Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Abut.</td>
<td>2</td>
<td>LRFD</td>
<td>446.00 ft</td>
<td>444.00 ft</td>
<td>None</td>
<td>424.00 ft</td>
<td>434.00 ft</td>
<td>1245 kips</td>
<td>34.00 ft</td>
<td>1</td>
<td>292.94 kips</td>
<td>109.85 kips</td>
<td>Steel HP 10 x 42</td>
<td>3.300 FT</td>
<td>4.806 FT</td>
<td>0.680 SQFT</td>
<td>0.086 SQFT</td>
</tr>
</tbody>
</table>

### IDOT Static Method of Estimating Pile Length

#### MAX Required Bearing & Resistance for Selected Pile, Soil Profile, & Losses

<table>
<thead>
<tr>
<th>Maximum Nominal Bearing of Pile</th>
<th>Maximum Nominal Reqd Bearing of Boring</th>
<th>Maximum Factored Resistance Available in Boring</th>
<th>Maximum Pile Driveable Length in Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>335 kips</td>
<td>335 kips</td>
<td>184 KIPS</td>
<td>60 FT</td>
</tr>
</tbody>
</table>

[Print Input Sheet] | [Print Pile Design Table]
[Clear Input Cells] | [Print Bearing Graph]
Round Eight – Submittal Requirements

- **Submittal Requirements for BB&S**
  - Type, Size & Location Drawing
    - General Plan & Elevation of Proposed Bridge
    - Waterway Information Table (W.I.T.)
  - Design Scour Table
  - Substructure Sketch

- Bridge Hydraulic Report
  - Design Scour Depths
- IDOT Form BLR 10210
- Soil Geotechnical Report (SGR)
  - Pile Capacity Sheets
Pitfall – Forgetting about other Disciplines

- Environmental
- Utilities
- Roadway
Coordination “Cheat” Sheet Handout

<table>
<thead>
<tr>
<th>Hydraulic Structure Coordination Data Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project: ____________________________</td>
</tr>
<tr>
<td>Project No. __________________________</td>
</tr>
<tr>
<td>Hydr. Engineer Contact: _______________</td>
</tr>
<tr>
<td>Structural Engineer Contact: ___________</td>
</tr>
<tr>
<td>Geotechnical Engineer Contact: _________</td>
</tr>
<tr>
<td>Project Scope Goal: ___________________</td>
</tr>
<tr>
<td>□ Complete Replacement</td>
</tr>
<tr>
<td>□ Superstructure Replacement</td>
</tr>
<tr>
<td>□ Superstructure Widening; Length of pier</td>
</tr>
<tr>
<td>□ Bridge</td>
</tr>
<tr>
<td>□ Culvert</td>
</tr>
<tr>
<td>□ New alignment</td>
</tr>
<tr>
<td>□ Minor Arterial</td>
</tr>
<tr>
<td>□ Collector</td>
</tr>
<tr>
<td>□ Principal Arterial</td>
</tr>
<tr>
<td>□ Local</td>
</tr>
<tr>
<td>Design Flood Frequency: □ 10-year □ 50-year □ Other: ______</td>
</tr>
<tr>
<td>Design Storm WSEL and Date: ____________</td>
</tr>
<tr>
<td>Datum of FIS Profile: ___________________</td>
</tr>
<tr>
<td>Datum of FIS Model: ____________________</td>
</tr>
<tr>
<td>Boundary Condition Location and Elevation(s): __________________</td>
</tr>
</tbody>
</table>

Tailwater or Backwater on Structure: ____________________________
History of Flooding or Overtopping problems: ____________________
Sources and Dates of Observed Highwater: _______________________
Sensitive Flood Receivers Location: ____________________________

Preliminary Proposed Structure Information

□ YES □ NO
Length: __________________
Low Beam Elevation: _________
Width of Deck: ______________
Total Length from face to face abutment: _______________________
Abutment type: __________________
Skew (structural): _____________
Skew (hydraulic): ______________
Number of Spans: ______________

Culvert: □ YES □ NO
Type and Size: __________________
US Invert elevation: ____________
DS Invert elevation: ____________
Lengths: _______________________
Entrance Type: __________________
Wing walls: ___________________

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