Scour Risk Management

Jerry R. Richardson, Ph. D., P.E., D. WRE
Associate Professor Civil Engineering UMKC
Senior Water Resource Engineer, WRS

Presented to:

Michigan Department of Transportation
Bridge Scour Technology Transfer Workshop

October 5, 2017
Rate your level of project uncertainty

- Risk is related to uncertainty.
- Uncertainty is difficult to quantify.
- Every Computational process in the scour analysis has uncertainty.

How often are you still uncomfortable, even though you designed for a particular flood event and used the recommended procedures?

What did you do about it?
Pick a Design Flood of level of acceptable risk

- NCHRP project 12–48 & Report 489
  - Revised Design Flood Exceedance probabilities for NEW Bridge design. Table 2.3

<table>
<thead>
<tr>
<th>Hydraulic design flood</th>
<th>Scour design Flood</th>
<th>Scour design Check Flood**</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{10}$</td>
<td>$Q_{25}$</td>
<td>$Q_{50}$</td>
</tr>
<tr>
<td>$Q_{25}$</td>
<td>$Q_{50}$</td>
<td>$Q_{100}$</td>
</tr>
<tr>
<td>$Q_{50}$</td>
<td>$Q_{100}$</td>
<td>$Q_{200}$</td>
</tr>
<tr>
<td>$Q_{100}$</td>
<td>$Q_{200}$</td>
<td>$Q_{500}$</td>
</tr>
</tbody>
</table>

**or worst case (i.e. incipient overtopping)

- Uncertainty in estimating design flows is related to Quantity/Quality/Type of hydrologic study.
The good news is that these recent studies provide a quantifiable level of risk for design relating to the remaining life of the structure. But there is still uncertainty in the method to determine design flows.

<table>
<thead>
<tr>
<th>Flood Frequency</th>
<th>Probability of Exceedance in N Years (or Assumed Bridge Design Life)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 1</td>
</tr>
<tr>
<td>Years</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10.0%</td>
</tr>
<tr>
<td>25</td>
<td>4.0%</td>
</tr>
<tr>
<td>50</td>
<td>2.0%</td>
</tr>
<tr>
<td>100</td>
<td>1.0%</td>
</tr>
<tr>
<td>200</td>
<td>0.5%</td>
</tr>
<tr>
<td>500</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

What is the real risk?
Contraction Scour Uncertainty

<table>
<thead>
<tr>
<th>Study conducted by Trained Personnel</th>
<th>Study conducted by Qualified Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1-D HEC-RAS</td>
<td>• 1-D HEC-RAS</td>
</tr>
<tr>
<td>• 2-D Steady Flow</td>
<td>• 2-D Steady Flow</td>
</tr>
<tr>
<td>• 2-D Unsteady Flow</td>
<td>• 2-D Unsteady Flow</td>
</tr>
<tr>
<td>• 3-D Unsteady</td>
<td>• 3-D Unsteady</td>
</tr>
<tr>
<td>• Physical Modeling (with 2 or 3-d model)</td>
<td>• Physical Modeling</td>
</tr>
</tbody>
</table>
Uncertainty–Scour Analysis Piers

- Complex piers (HEC-RAS)
- Complex piers (2-D)
- Simple Pier Walls (HEC-RAS)
- Simple Pier Walls (2-D)
- Circular Piers

Note:
Uncertainty strongly influenced by angle of attack

Predicting pier scour in soils other than sand increase uncertainty

Deviation from ideal lab conditions increase uncertainty
Uncertainty–Scour Analysis–Abutments

- Froehlich
- HIRE
- NCHRP 24–20 1–D
- NCHRP 24–20 2–D
  (abutments near channel)

- Froehlich
- HIRE
- NCHRP 24–20 1–D
- NCHRP 24–20 2–D
  (abutments Set Back from channel)
Risk and reliability–based methodology linking scour depth estimates to a probability consistent with load and resistance factor design (LRFD)

Assessment of variability of scour estimates from Monte–Carlo simulation considering the variability of individual hydraulic and scour computations.

Uncertainties associated with bridge scour prediction—
- Simple bridge–conditional probability of exceedance
- Complex Channel/Pier step–by–step procedure for scour factors
Strategies for reducing uncertainty risk

Option 1 Increase level of conservativism
• “When in doubt-he** for stout”
• Relatively modest Engineering costs $
• Relatively large structure and construction cost $$$$$

Option 2 Find an “expert” to invoke “Engineering Judgment”
• Shifts risk to someone else ? (maybe)
• Low Cost Alternative? (if all goes right)
Strategy 3
Risk Based Approach
• NCHRP 761 approach
• Multi-parameter analysis
• More consistent scour analysis from a broad population of analysts of varying expertise.

Strategy 4
Utilize experts using more level 3 tools
• Significantly narrows the uncertainties within each process.
• Larger Engineering costs $
• Design and CM targeted to specific scour issues
• Reduced structure and construction cost $$.
However, more data does not always reduce uncertainty. Techniques that were developed for sparse data often deteriorate when high density data is used.
OR

Allowing skilled experts to apply advanced tools and knowledge will.