Observation Method for Estimating Future Scour Depth at Existing Bridges

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Bridge scour
“Scour Critical Bridge” means

- Foundation is unstable for calculated and/or observed scour conditions

- 17,000 in the U.S.

- 600 in Texas
Scour Critical Bridges

Bridges are classified scour critical because:

- Observed excessive scour
- Predicted excessive scour

Predicted excessive scour could be due to an over-conservative prediction method, to a more erosion resistant soil than assumed, to not using other methods capable of overcoming over-conservatism because they are more expensive.
**Observation Method for Bridge Scour**

- **Step 1:** Observe maximum scour depth $= Z_{mo}$

- **Step 2:** Find out the maximum flood the bridge has been subjected to $= V_{mo}$

- **Step 3:** Extrapolate field measurements to predict future scour depth
  \[
  \frac{Z_{fut}}{Z_{mo}} = \frac{V_{fut}}{V_{mo}}
  \]

- **Step 4:** Compare future scour depth to foundation depth
  \[
  Z_{fut} < \frac{Z_{found}}{2}
  \]
Drawbacks

- Problem with in filling
- Requires a good network of flow gages and rain gages
- Cannot be used for new bridges
Advantages

• No need for erosion testing
• Actual soil
• Actual flow history
• Actual geometry
• Based on observed measurements
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\[
\frac{V_{fut}}{V_{mo}} = \frac{Z_{fut}}{Z_{mo}}
\]

• **Step 4:** Compare future scour depth to foundation depth

\[
Z_{fut} < \frac{Z_{found}}{2}
\]
Step 1: Observe maximum scour depth = $Z_{mo}$

$Z_c = \text{Contraction Scour}$

$Z_p = \text{Pier Scour}$

$Z_a = \text{Abutment Scour}$
Observation Method for Bridge Scour

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  Z_{fut} < \frac{Z_{found}}{2}
  \]
Step 2: Find out the maximum flood the bridge has been subjected to = $V_{mo}$

Case 1: Flow data available at the bridge
Use the flow record and identify the highest value $Q_{mo}$. Transform $Q_{mo}$ into $V_{mo}$ (TAMU-FLOW)

Case 2: Flow data not available at the bridge
Use data from neighboring gages and interpolate to find $Q_{mo}$. Transform $Q_{mo}$ into $V_{mo}$ (TAMU-FLOW)
Step 2: Find out the maximum flood the bridge has been subjected to = $V_{mo}$
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Maximum Flow map between 1970 and 2005

Automated with TAMU-FLOOD software (free on internet)
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Step 3: Extrapolates field measurements to predict future scour depth $\frac{Z_{fut}}{Z_{mo}} = \frac{V_{fut}}{V_{mo}}$

- Known = $Z_{mo}$ and $V_{mo}$
- Choose $V_{fut}$
- Obtain $Z_{fut}$ from charts
Step 3: Extrapolates field measurements to predict future scour depth $Z_{fut}/Z_{mo} = V_{fut}/V_{mo}$

The Z-Future Charts were developed by performing a large number (~350,000) of HEC-18 Clay simulations using

- Varying pier & contraction scour geometry
- Varying soil conditions
- Varying velocities
- Varying age of the bridge
Step 3: Extrapolates field measurements to predict future scour depth \( \frac{Z_{\text{fut}}}{Z_{\text{mo}}} = \frac{V_{\text{fut}}}{V_{\text{mo}}} \)

Category III Material
- Upstream Water Depth \( (H_1) \): 5m to 20m
- Contraction Ratio \( (R_C) \): 0.5 to 0.9
- Critical Velocity \( (V_c) \): 0.5 m/s
- Pier Diameter \( (D) \): 0.1m to 1.0 m

\( t_{\text{hyd}} \) = 5 years
\( t_{\text{hyd}} \) = 25 years
\( t_{\text{hyd}} \) = 50 years
\( t_{\text{hyd}} \) = 75 years
Step 3: Extrapolates field measurements to predict future scour depth $Z_{fut}/Z_{mo} = V_{fut}/V_{mo}$

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River Bed before Scour
River Bed after Scour
• Collected 9 case histories with
  – Channel profile measurement records
  – Flow data
  – Soil information
  – Foundation information
  – Current scour status
VERIFICATION

Velocity (m/s) vs Year

- \( V_{mo,i} \) and \( V_{fut,i} \)
- Year built
- i-th measurement: \( Z_{mo,i} \)
- (i+1)-th Measurement: \( Z_{fut,i} \)
APPLICATION TO SCOUR CRITICAL BRIDGES

- 16 bridges selected (12 scour critical, 3 stable)
- 6 scour critical bridges out of the 12 found stable by the observation method
- 3 stable bridges found stable by the observation method
- 6 of 12 bridges originally classified scour critical were found stable by the observation method
RECOMMENDATION

- Lets extend TAMU-FLOOD to all States