Envelope Curves for Assessing Scour in South Carolina

by

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Envelope Curves for Assessing Scour in South Carolina

- Project Overview -
- Data Collection -
- Predicted vs. Observed -
- Envelope Curves -

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Project Objectives

- Collection of clear-water bridge-scour data
  - Lower Coastal Plain
    - Swampy
    - Noncohesive sandy materials
  - Piedmont
    - Scour on overbanks
- Analysis of the data
  - Compare theoretical scour to observed scour
  - Investigate relations in the observed data
- Obtain a snapshot of scour in SC

Historic scour is a good indicator of future scour
Focused on CLEAR-WATER scour

- Scour hole does not refill
- Allowed site visits at any time (low-flow)
- Focus on older bridges or bridges known to have experienced a significant flood
- **Advantage**
  - Data collection not dependent on floods
  - Data reflects maximum historic scour
- **Disadvantage**
  - Uncertainty associated with conditions that caused the scour
Data Collection

- Abutment Scour
  - Bridges < 240 ft in length
    - 1 scour hole
  - Bridge > 240 ft in length
    - 2 scour holes
Big Swamp at Route SC 51
Florence County, South Carolina

Scour Hole
100 ft

Scour Hole
10 ft
Coosawhatchie River at Road S-87
Jasper County, South Carolina

- Flow
- 570 ft
- Abutment Scour Holes
- 6 feet
- 7 feet
Data Collection

- Contraction Scour
  - Clear-water
Collection of Overbank Contraction Scour

Collect reference-surface elevation and low point of scour hole
Overbank Contraction Scour in the Piedmont
Data Collection

• Pier Scour
  – Clear-water
  – Overbank area
Pier Scour

Pier width = 1.5 ft

Scour depth = 0.9 ft
Collection of Pier-Scour Data in the Piedmont

Anderson County
Rocky Creek at Rd. S-263
Collection of Pier-Scour Data in the Piedmont

Fairfield County
Little Wateree Creek at I 77
Distribution of Clear-Water Scour Sites

- Scour site
Comparison of Field and Predicted Data

The Froehlich Abutment Scour Equation compares observed and theoretical abutment-scour depth data. The line of agreement indicates the points where the observed and predicted values match. The data is divided into Piedmont and Coastal Plain categories.
Comparison of Field and Predicted Data

Laursen Contraction Scour Equation

Line of Agreement

- COASTAL
- PIEDMONT
- NATIONAL

PREDICTED CONTRACTION SCOUR, IN FEET

MEASURED CONTRACTION SCOUR, IN FEET
Comparison of Field and Predicted Data

HEC-18 Pier Scour Equation

Line of Agreement

PREDICTED PIER-SCOUR DEPTH, IN FEET

OBSERVED PIER-SCOUR DEPTH, IN FEET

PIEDMONT

COASTAL
Perspective on Envelope Curves

- **Sediment transport is an inexact science**
  - unlikely to find universal equation in near future

- **Envelopes are used in lab analysis**
  - can use similar pattern for field data

- **Dominant explanatory variables in lab are geometry**
  - should expect similar pattern in field data

- **Scour driven by hydrology, geology, and geometry**
  - therefore should expect regional trends
  - South Carolina curves will not work in Alaska
Envelope Curves

- Abutment Scour -
Definition of Embankment Length

Flow

1,550 ft

570 ft
Embankment Length Envelope

Laboratory Data

Piedmont Field Data
Embankment Length Envelope
Piedmont

Equation for envelope curve
\[ y_s = -0.000009L^2 + 0.0276L \]
for \( L \leq 950 \)

Legend:
- Solid line: envelope curve based on a trend line through the points identified by circles
- Black circle: observed abutment scour from field investigation
- White circle: data points arbitrarily chosen to develop envelope curve and equation
- \( y_s \): estimate of abutment scour depth along envelope curve, in feet
- \( L \): 100-year flow embankment length, in feet (not to exceed 950 feet)
Embankment Length Envelope Piedmont

Envelop curve

1995 flood

- Envelope of field data
- Observed abutment scour for all Piedmont sites
- Observed abutment scour from 1995 flood
Envelope Curves

- Contraction Scour -
Definition of Geometric Contraction Ratio

\[ 1-b/B = 1 - \frac{570}{3440} = 0.83 \]
Overbank Contraction Scour

EXPLANATION
- Measured clear-water contraction scour for selected sites in the Coastal Plain of South Carolina
- Measured clear-water contraction scour for selected sites in the Piedmont of South Carolina (from Benedict, 2003)
- $y_s = -6m^2 + 10m + 0.6$
  where $m < 0.95$

Other symbols:
- Estimate of contraction-scour depth along envelope curve, in feet
- 100-year flow geometric-contraction ratio (not to exceed 0.95)
Envelope Curves

- Pier Scour -
Pier Scour in the South Carolina Laboratory Data

Field Data

**EXPLANATION**
- Laboratory data used to develop the original HEC-18 pier scour equation (Richardson and others, 1991)
- Laboratory data from Melville and Chiew (1999)
- Envelope for HEC-18 data
- Envelope for Melville and Chiew (1999) data

**Equations**
- \( y_s = 1.95b + 0.1 \)
- \( y_s = 0.9b + 0.24 \)

**Symbols**
- \( y_s \): Pier-scour depth, in feet
- \( b \): Pier width, in feet

**USGS**
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Envelope Curves

- Very simple but useful tools
- Based on field data offering an advantage over lab relations
- Gives engineer a tool for making judgment calls
- Other states can do these types of projects and meet with success


Questions?

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