FHWA’s Future Scour Design Approach

presented at the

Bridge Scour Technology Transfer Workshop

in

Dimondale, Michigan

by

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Concept of Hydraulic loading and Erosion force Decay Function

2018

Physical Modeling 35%
Numerical Modeling 65%
Concept of Hydraulic loading and Erosion force Decay Function

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Concept of Soil Erosion Resistance

Level 1: Using current assumptions of uniform soil (e.g. $D_{50}$)

- Factored Resistance
- Nominal Resistance
- Estimated $y_s$
- True $y_s$

ASSUMED UNIFORM SOIL
2018

Physical Modeling 35 %
Numerical Modeling 65 %

Concept of Soil Erosion Resistance
Level 2: Soil Erosion Resistance Data from Historical Records

Boring Logs from Historical Records

- Factored Resistance
- Nominal Resistance
- Level 2 Uncertainty
- Estimated \( y_s \)
- True \( y_s \)

2018

Physical Modeling 35 %
Numerical Modeling 65 %

Concept of Soil Erosion Resistance
Level 2: Soil Erosion Resistance Data from Historical Records

Boring Logs from Historical Records

- Factored Resistance
- Nominal Resistance
- Level 2 Uncertainty
- Estimated \( y_s \)
- True \( y_s \)
Concept of Soil Erosion Resistance

Level 3: Soil Erosion Resistance from Geotechnical Properties

Soil Erosion Resistance = f (Pl, Cu, ...)

Physical Modeling 35%
Numerical Modeling 65%

2018

Soil Erosion Resistance = f (Pl, Cu, ...)

Factored Resistance
Nominal Resistance

True \( y_s \)
Estimated \( y_s \)

Level 3 Uncertainty

Soil Erosion Resistance = f (Pl, Cu, ...)

Physical Modeling
Numerical Modeling

2018

Soil Erosion Resistance = f (Pl, Cu, ...)

Factored Resistance
Nominal Resistance

True \( y_s \)
Estimated \( y_s \)

Level 3 Uncertainty

Soil Erosion Resistance = f (Pl, Cu, ...)

Physical Modeling
Numerical Modeling

2018
2018
Physical Modeling 35 %
Numerical Modeling 65 %

Concept of Soil Erosion Resistance
Level 4: Soil Erosion Resistance from Lab Erosion Testing

Shelby Tube Sample for Lab Erosion Testing

Factored Resistance
Nominal Resistance

True $y_s$
Estimated $y_s$

Level 4 Uncertainty

2018
Physical Modeling 35 %
Numerical Modeling 65 %

Concept of Soil Erosion Resistance
Level 4: Soil Erosion Resistance from Lab Erosion Testing

Shelby Tube Sample for Lab Erosion Testing

Factored Resistance
Nominal Resistance

True $y_s$
Estimated $y_s$

Level 4 Uncertainty
Physical Modeling 30 %
Numerical Modeling 70 %

Hydraulics Lab Overview

Automation of Soil Erosion Resistance Experiments

Programmed Robotic Arms performing experiments
2030
Physical Modeling 20%
Numerical Modeling 80%

Potential Future Procedure for Determining Soil Erosion Resistance
Hydraulic Loads
MFS and CFD to Determine Shear Erosion Forces

Example: Feather River Bridge, Sacramento, CA, Scour Study
MFS and CFD to Determine Shear Erosion Forces (cont'd)
Digitized Scour Bathymetry
Digitized Scour Bathymetry (cont’d)
Digitized Scour Bathymetry (cont'd)

$y_s$

9.5 ft

9.5 ft
Digitized Scour Bathymetry (cont’d)
CFD for Computing Decay of Shear Erosion Forces

21 Pa

Shear Stress
CFD for Computing Decay of Shear Erosion Forces (cont’d)

Shear Stress

13 Pa

5 ft

13 Pa

$y_s$
CFD for Computing Decay of Shear Erosion Forces (cont’d)

$\gamma_s$ → Shear Stress

8 ft → 10 Pa

10 Pa → 10 Pa
CFD for Computing Decay of Shear Erosion Forces (cont’d)
CFD for Computing Decay of Shear Erosion Forces (cont’d)
Soil Erosion Resistance – Testing

• In-situ Scour Testing Device
Proposed Future Scour Depth Design Method
Proposed Future Scour Depth Design Method (cont’d)
Proposed Future Scour Depth Design Method
(cont’d)

In Situ Scour Testing Device (ISTD)
Proposed Future Scour Depth Design Method (cont'd)

In-situ Scour Testing Device Research
In-situ Scour Testing Device Concept (cont'd)
In-situ Scour Testing Device Concept (cont’d)
In-situ Scour Testing Device Concept (cont’d)
Step 1: Standard drilling using auger with casing
Soil Erosion Resistance - Testing

- Ex-situ Scour Testing Device
Erosion Rate Curve is used for determining the Critical Soil Erosion Resistance ($\tau_c$)}