

GRS-Abutment Study: Interaction between Riprap Countermeasures and Contraction Scour

presented

by

Oscar Suaznabar, Zhaoding Xie
and Kornel Kerenyi

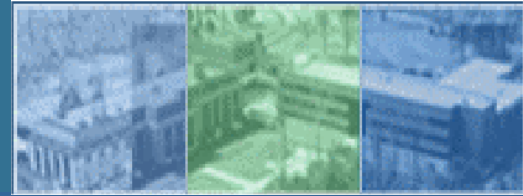
at the

NHEC

Thursday, August 21, 2014

Iowa City, IA

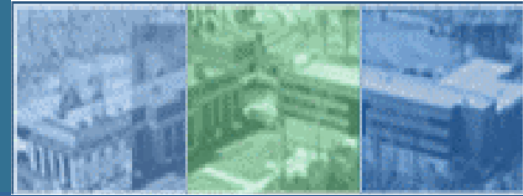




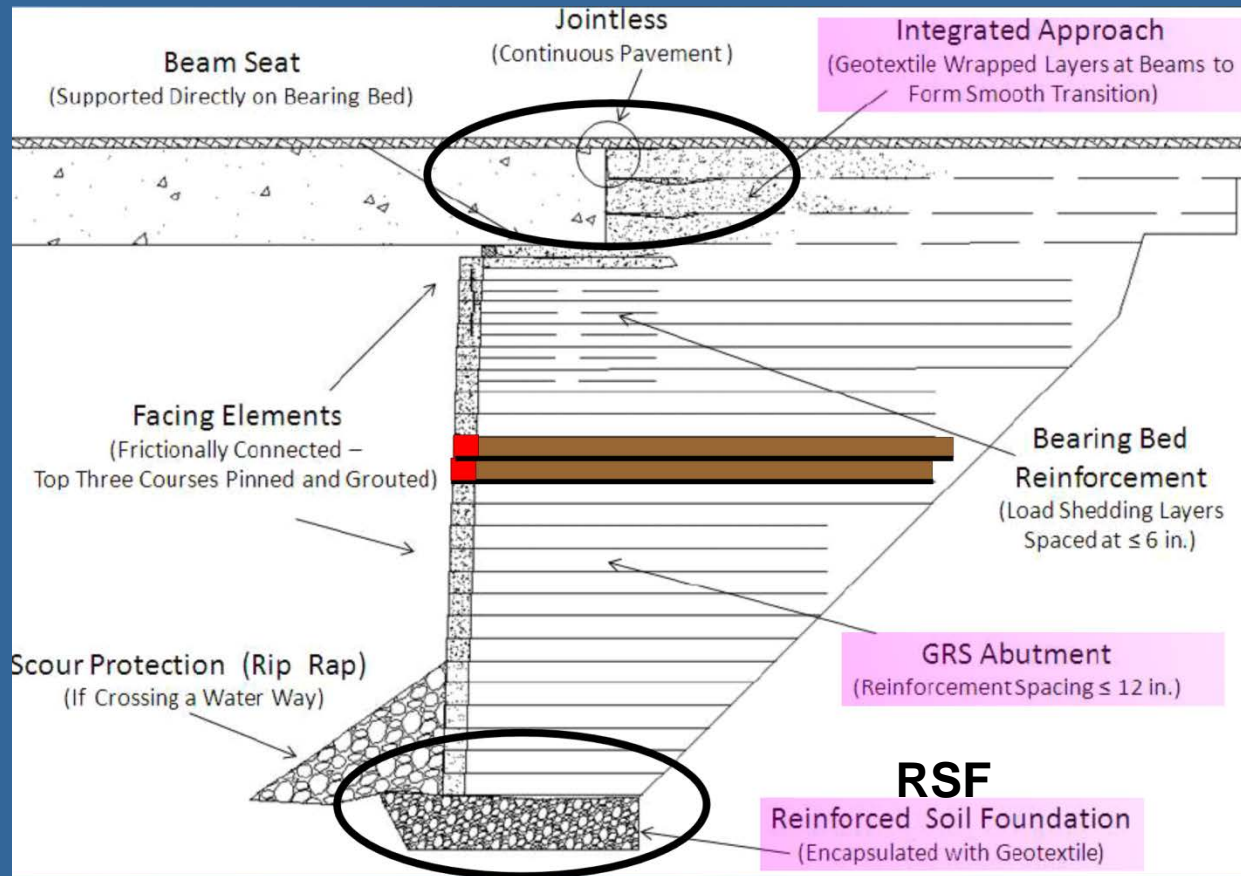
Outline

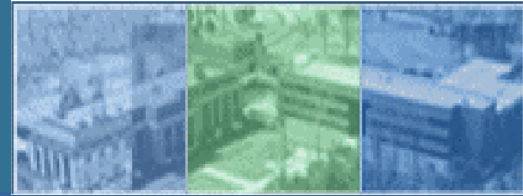
- GRS Abutments: Brief Overview of technology
- GRS Abutment Model
- Riprap Countermeasure Research
- Open Discussion





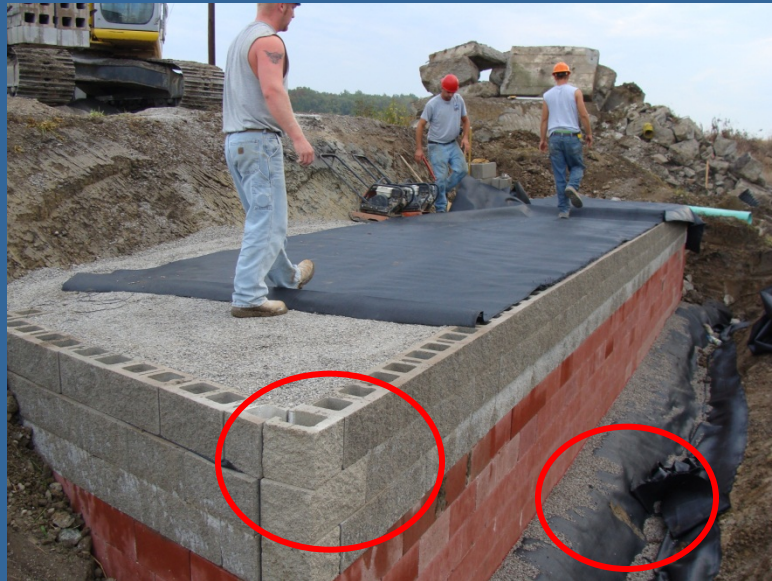
Cross-Section of GRS-IBS Abutment





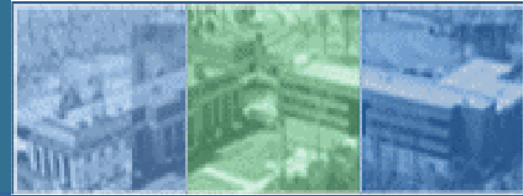
GRS Abutment: Hydraulic Analysis Motivation

1. Frictional Connection of Facing Blocks
2. RSF is a Shallow Foundation / Scour
3. Riprap Installation for Narrow Bridge Openings

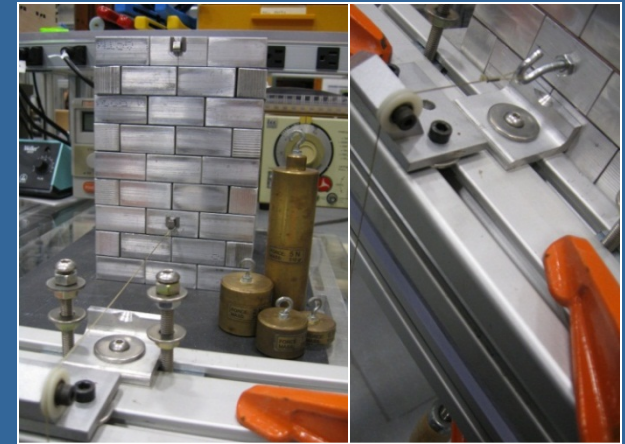


About 175 bridges under design
or built in 39 States





GRS Abutment: Physical Model

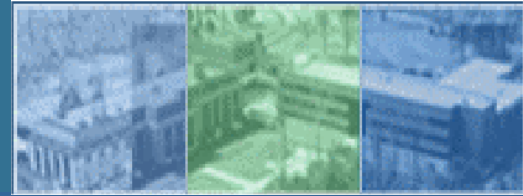


Calibrating Friction Coefficient
Block Pull-Out tests



GRS Abutment
During Construction



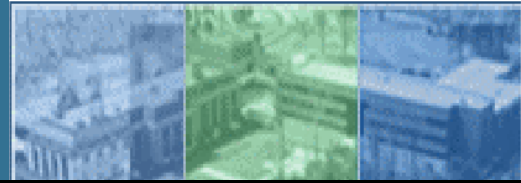


Performance of Facing Blocks Frictional Connection



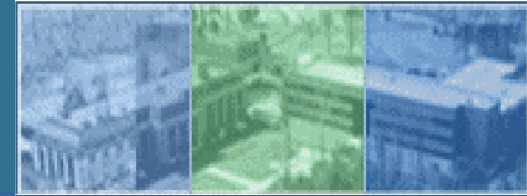
Facing Blocks Connection tested
for Q_{100} Flow Velocities
Corresponding to 6 – 10 ft/s





GRS Abutment Scour Test (No Riprap)





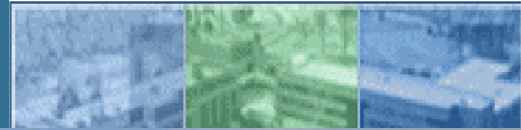
GRS Abutment: Shallow Foundation / Scour



Failure of CMU Blocks due to
Unstable Shallow RSF foundation

Undermined RSF Foundation
settled into the scour hole



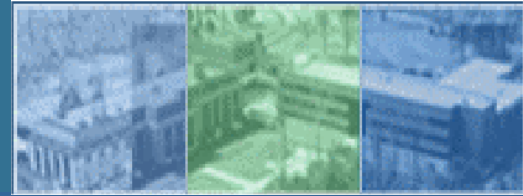


Riprap Countermeasure Research

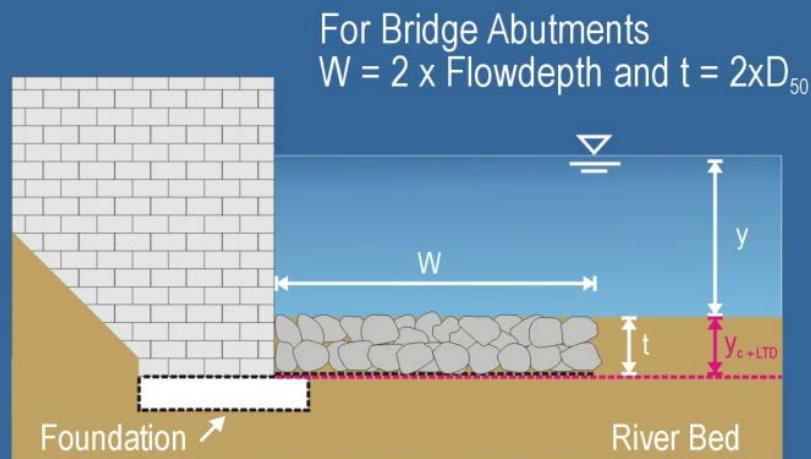


Riprap Installations in the Field

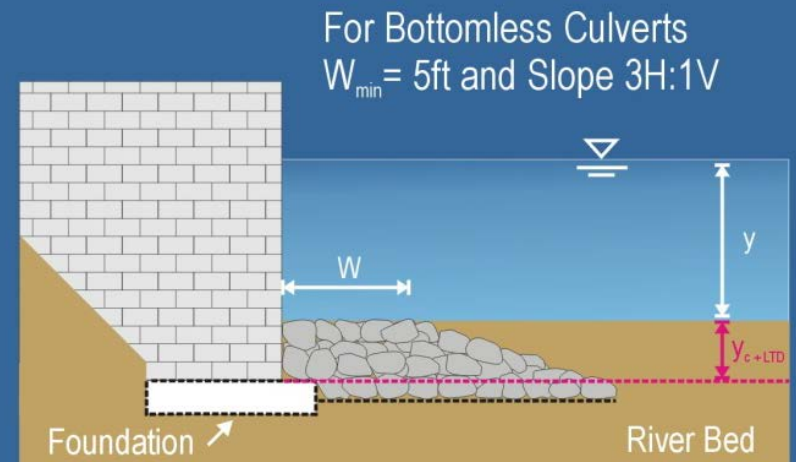




HEC-23 Riprap Installation



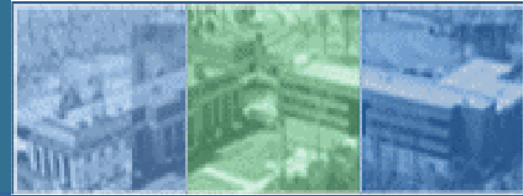
HEC-23 D.G.14
for Bridge Abutments



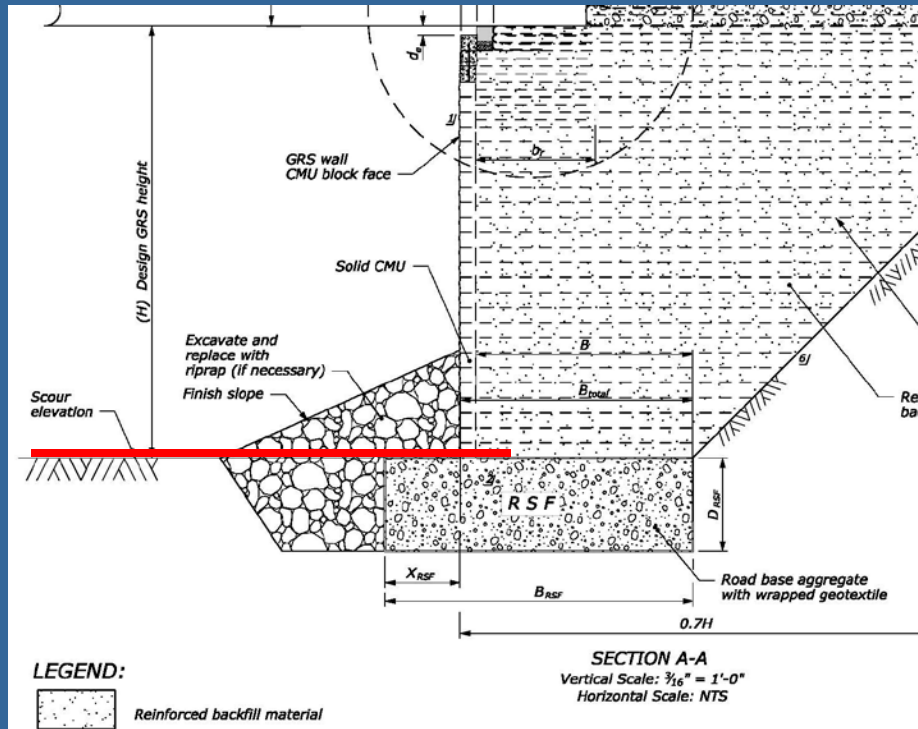
HEC-23 D.G.18
for Bottomless Culverts

GRS-IBS Implementation Guide

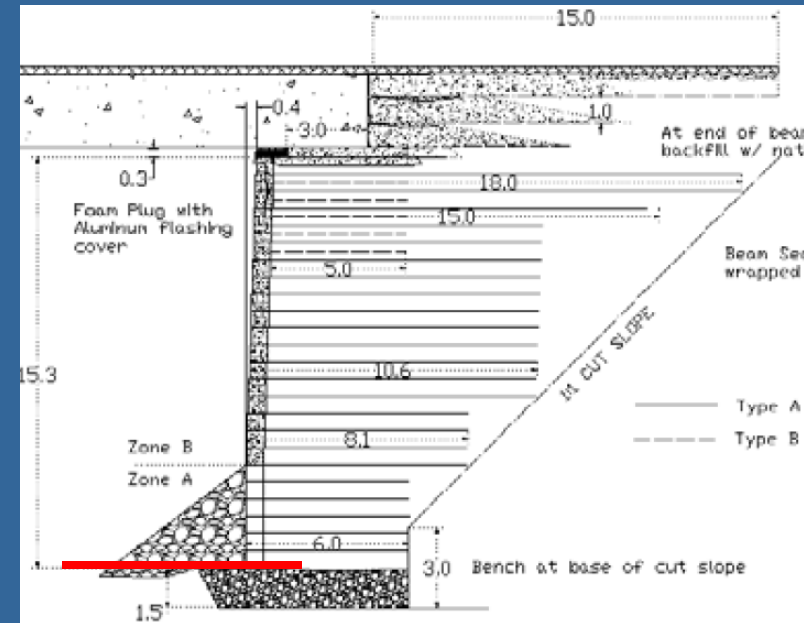




Riprap Installation in the Fields Cont'd

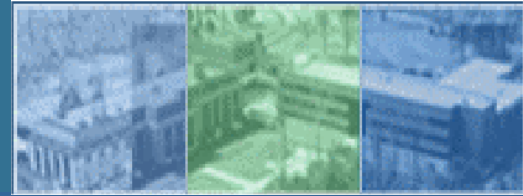


GRS-IBS Design Drawings 2011

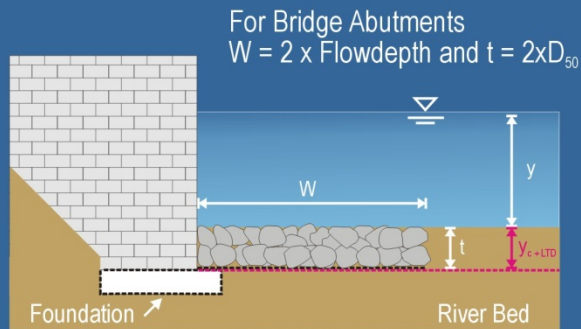


Bowman Road Bridge
Riprap Slope 2:1

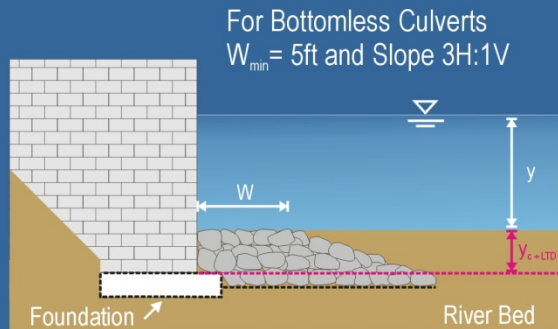




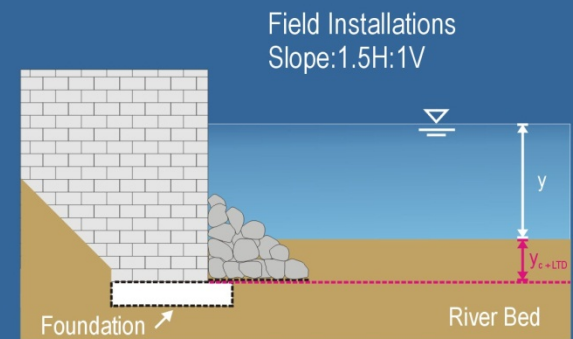
Riprap Installation Performance: Clear Water Scour



HEC-23 D.G.14

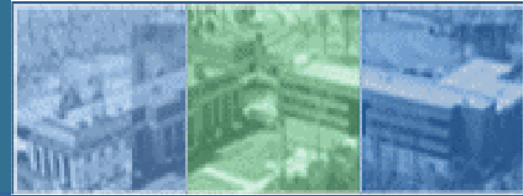


HEC-23 D.G.18



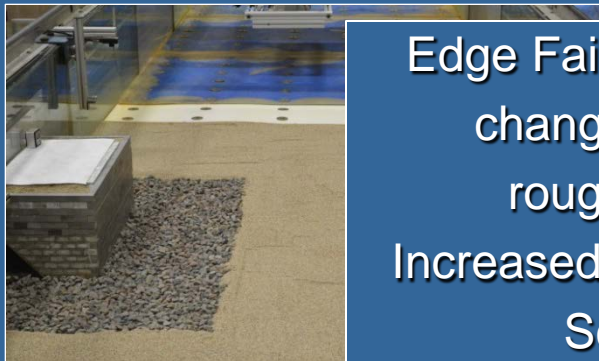
Side Slope Installation





Riprap Installation Performance: Clear Water Scour

HEC-23 D.G.14

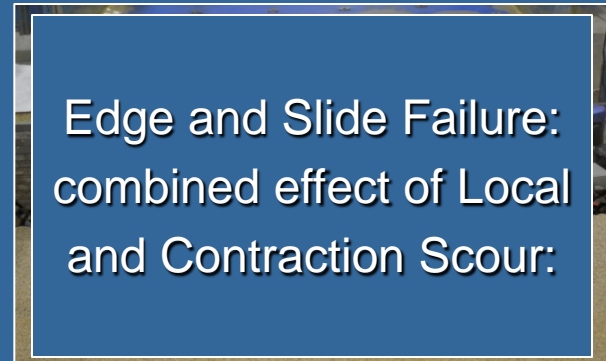


Edge Failure: Due to change of bed roughness:
Increased Contraction Scour

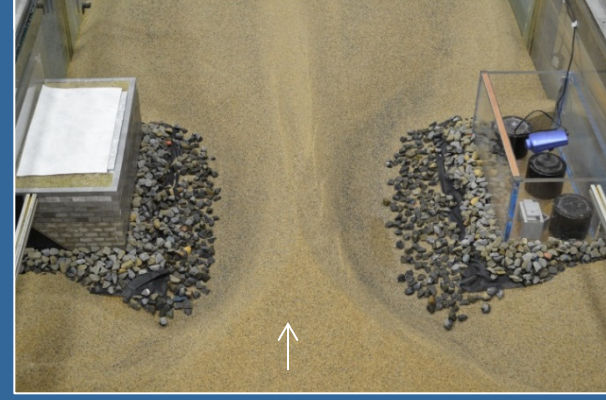
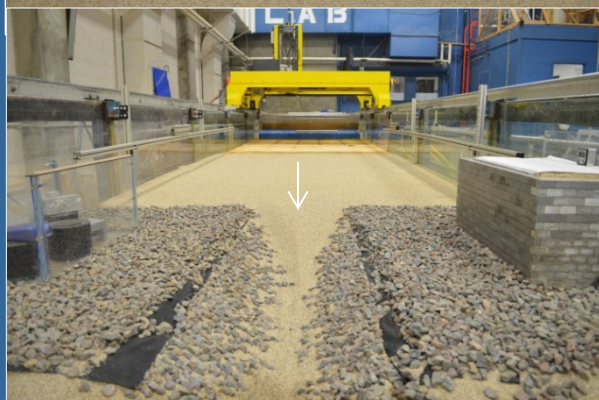
HEC-23 D.G.18

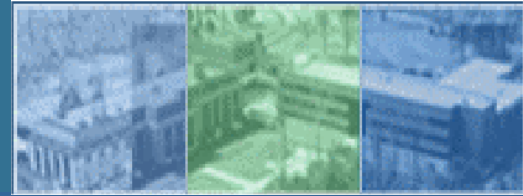


Side Slope Installation



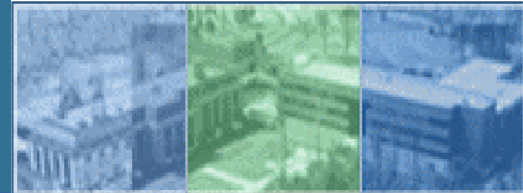
Edge and Slide Failure:
combined effect of Local
and Contraction Scour:





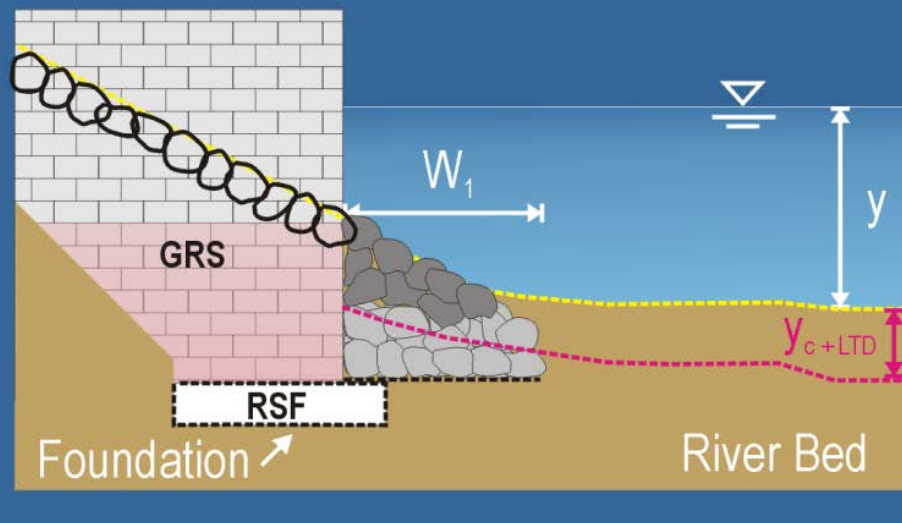
Riprap Installation for Narrow Bridge Openings





Riprap Installation for Narrow Bridge Openings

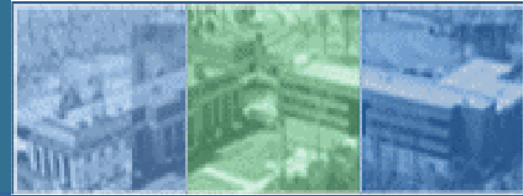
Riprap Field Installation 1



River Bed

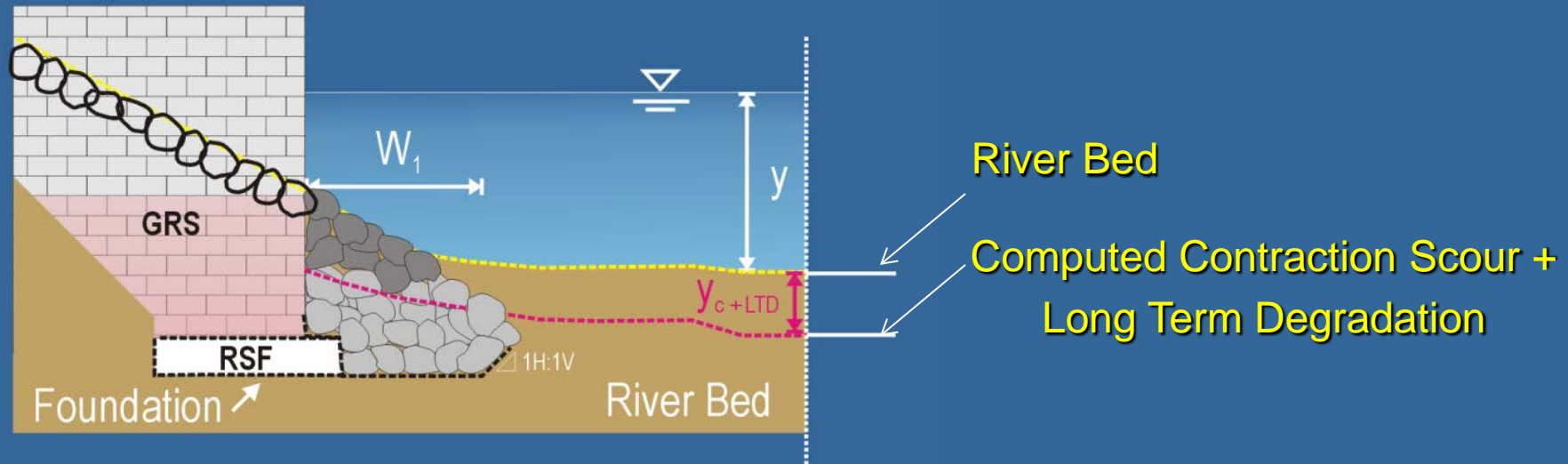
Computed Contraction Scour +
Long Term Degradation





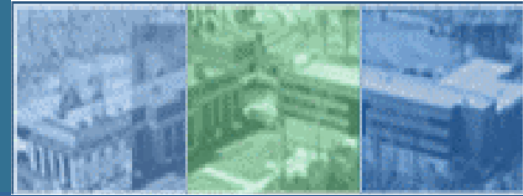
Riprap Installation for Narrow Bridge Openings

Riprap Field Installation 2



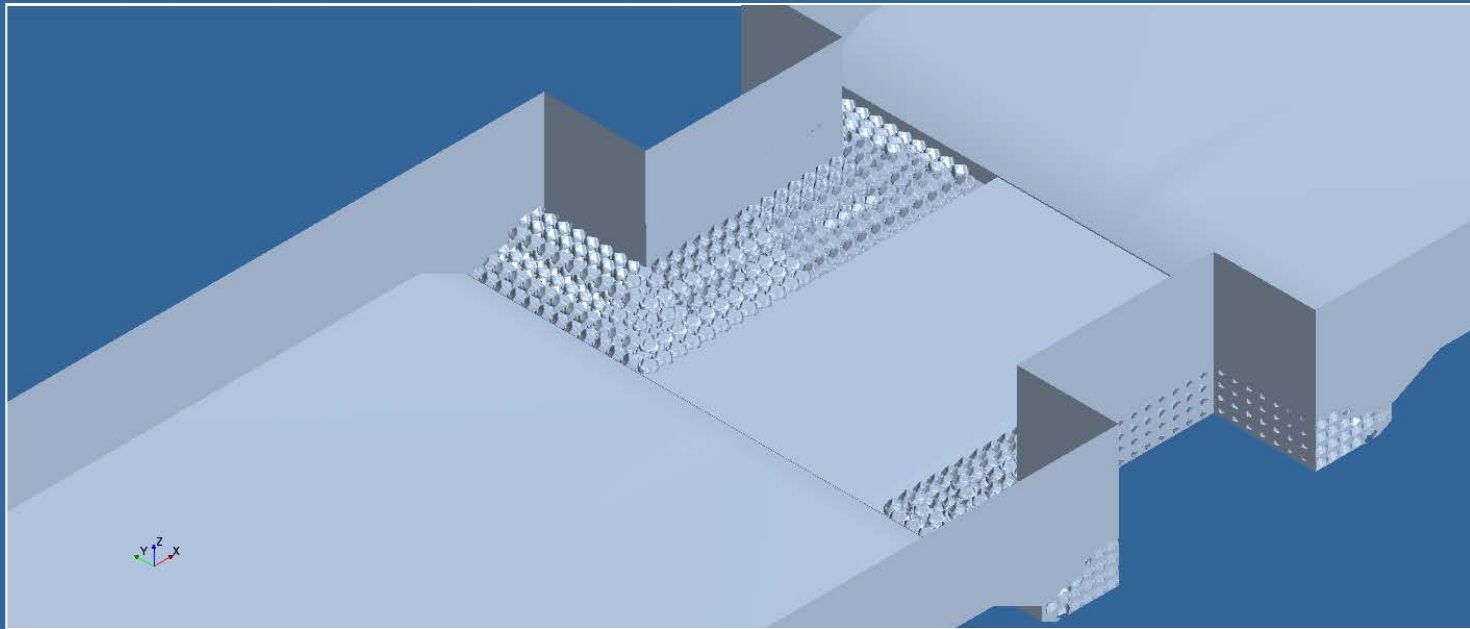
Riprap apron extent W_1 into the Main Channel depends on Bank Slope for a smooth transition

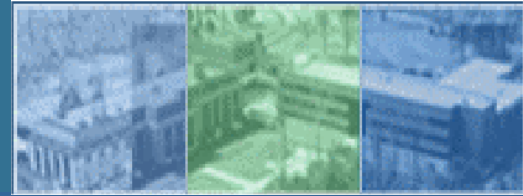




CFD Simulation for Riprap around Abutment

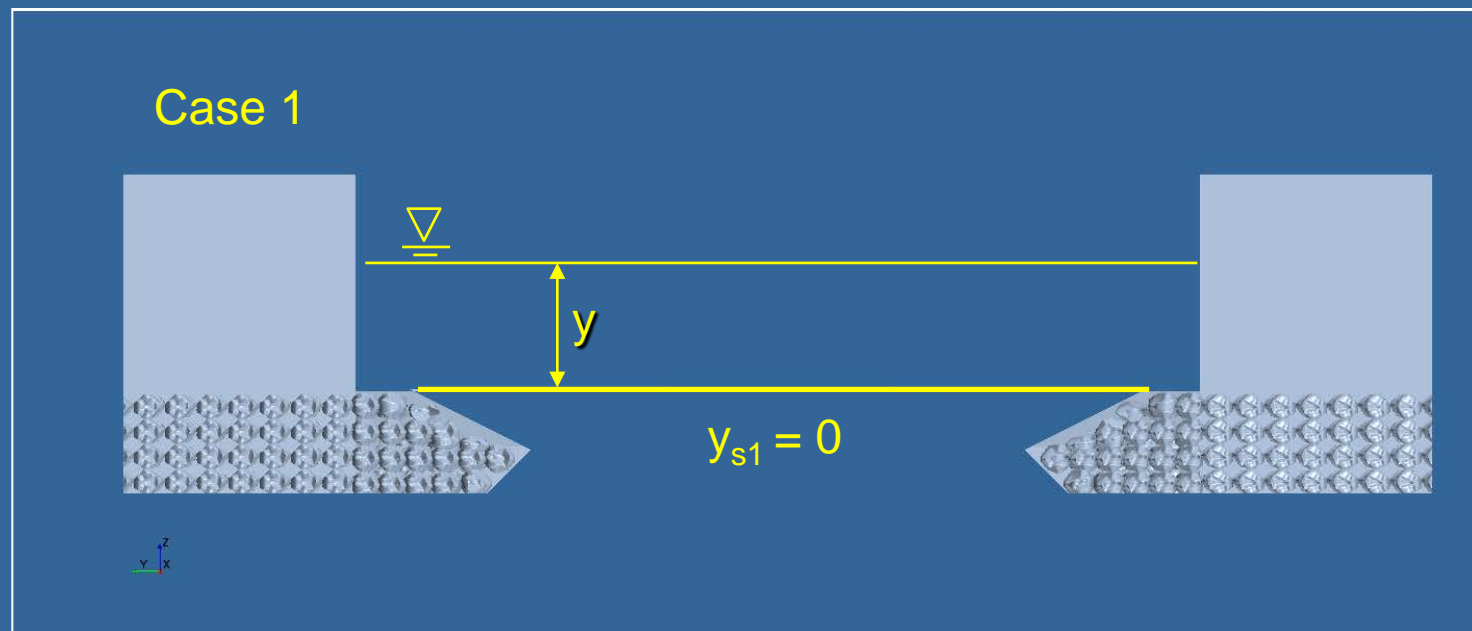
3D Model

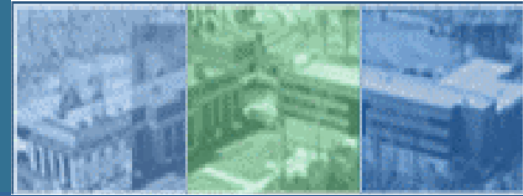




CFD Simulation for Riprap around Abutment

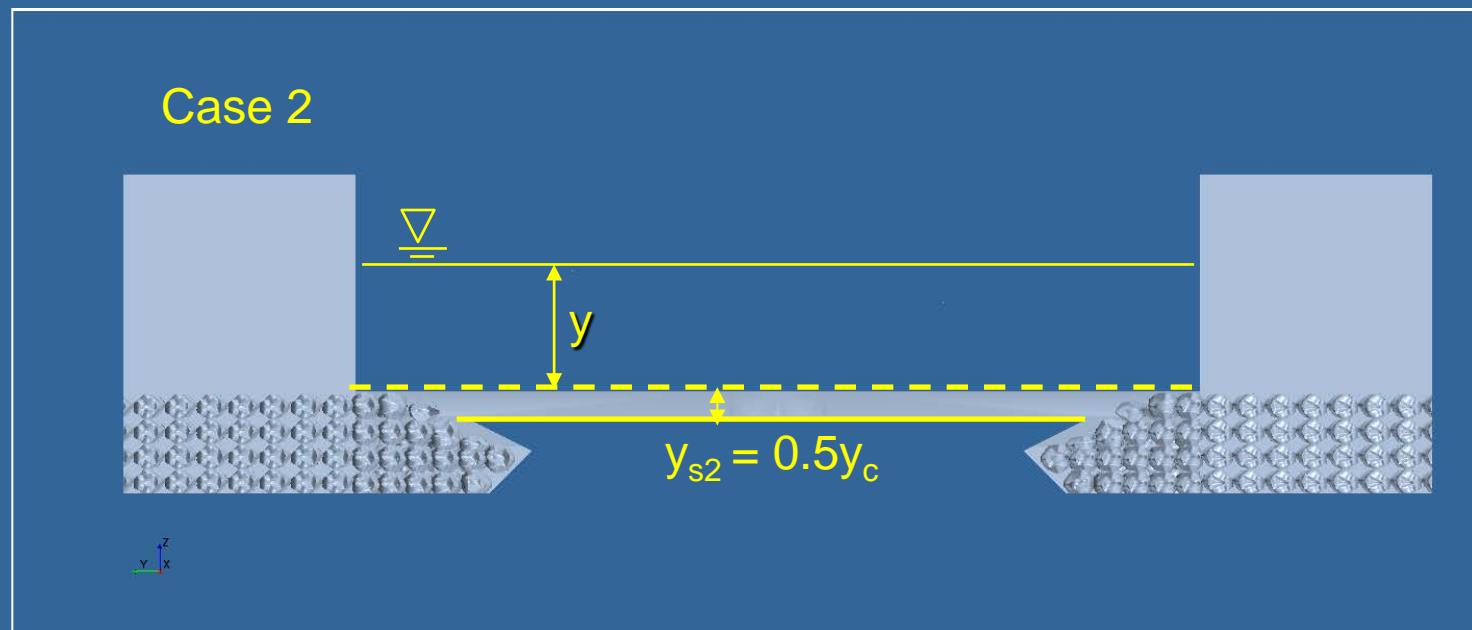
Stage 1: Simulation for Riprap
Countermeasure around Abutment

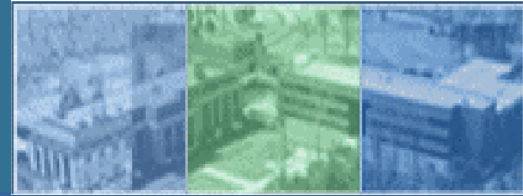




CFD Simulation for Riprap around Abutment

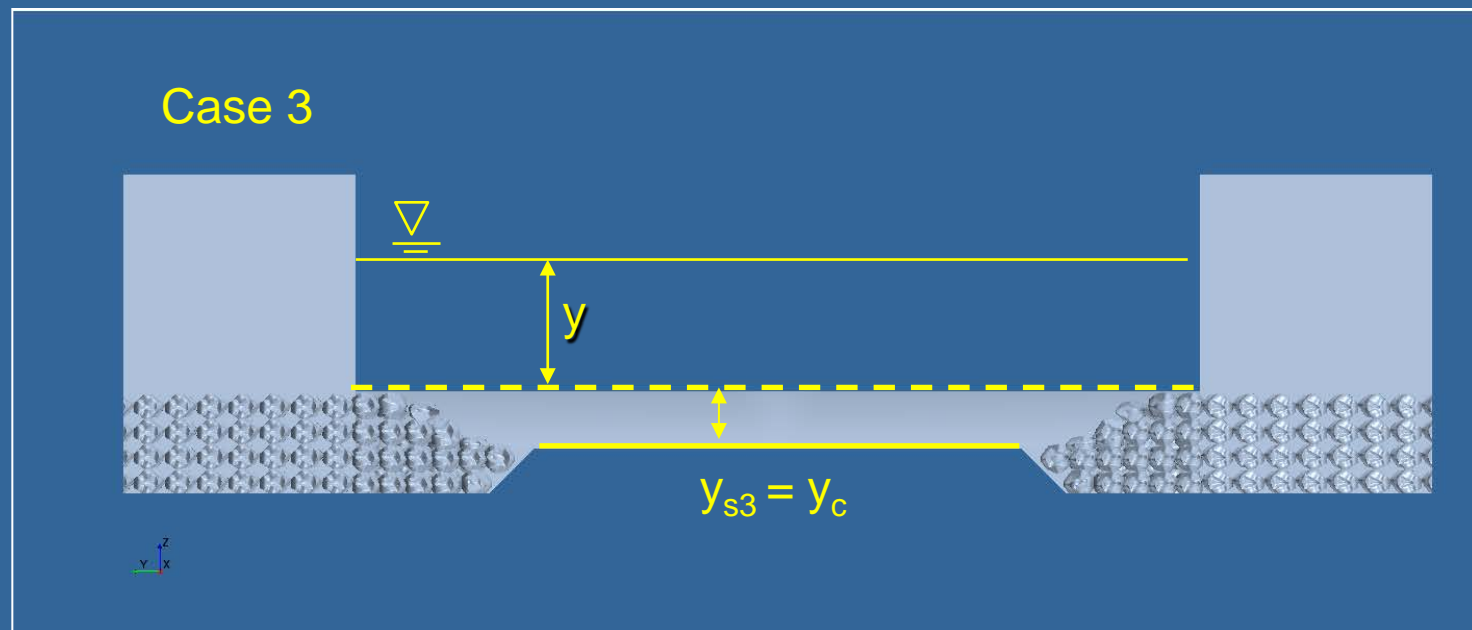
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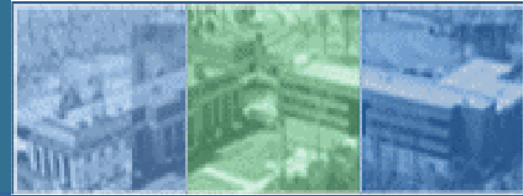




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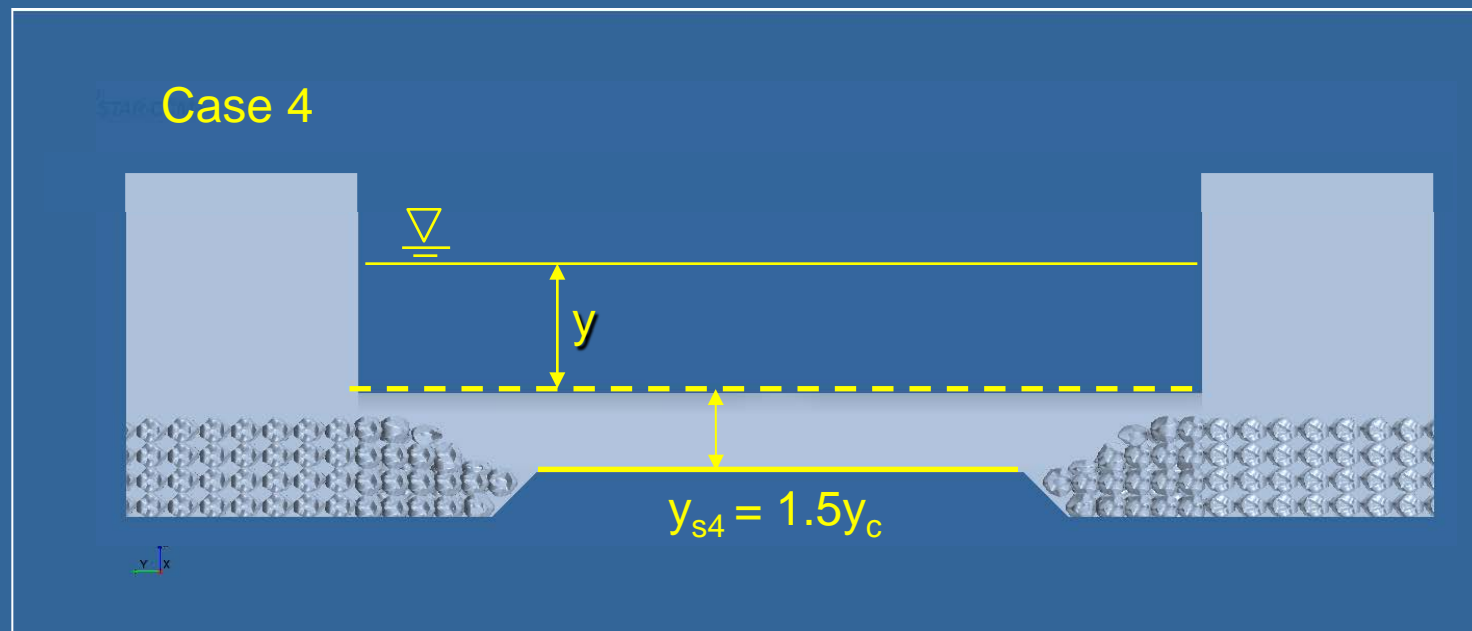
Stage 1: Simulation for Riprap
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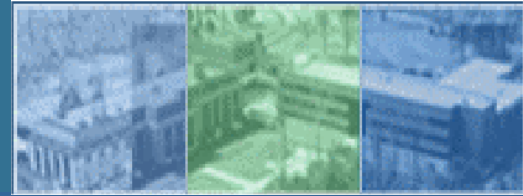




CFD Simulation for Riprap around Abutment

Stage 1: Simulation for Riprap
Countermeasure around Abutment





CFD Simulation for Riprap around Abutment

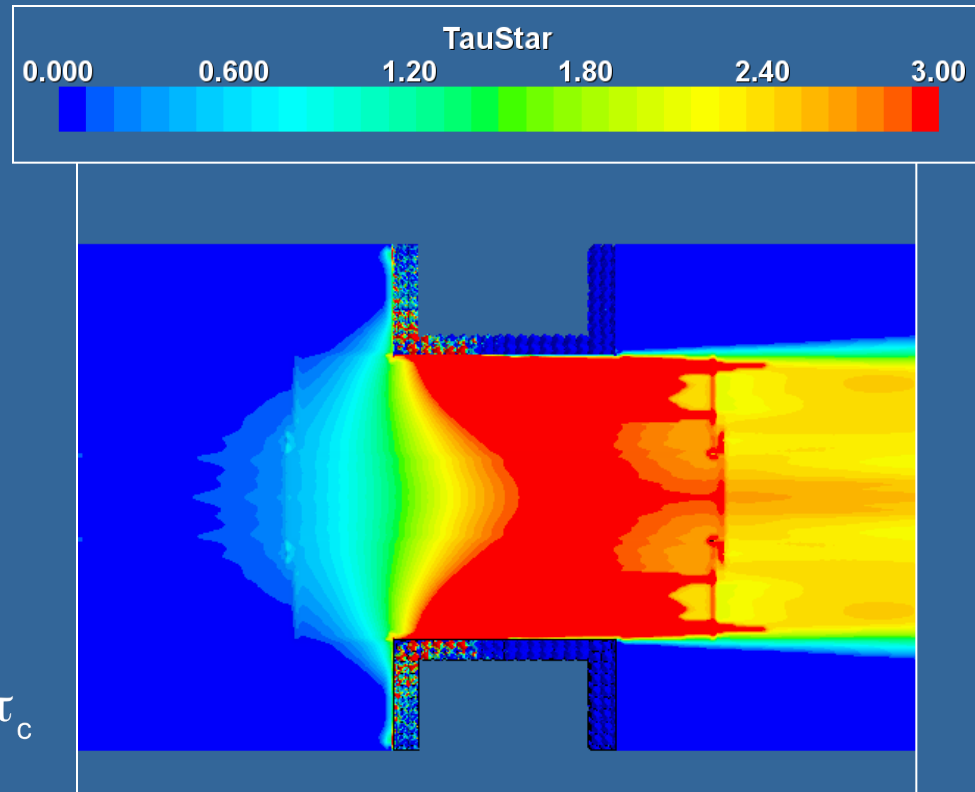
Case1



Flow

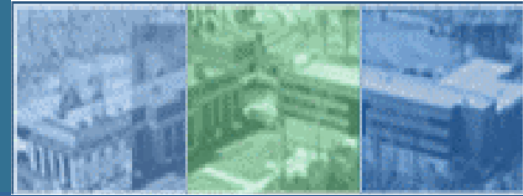
$$\text{TauStar} = (\tau - \tau_c) / \tau_c$$

$$\tau_c = 0.371 \text{ pa}$$



Excess Shear Stress





CFD Simulation for Riprap around Abutment

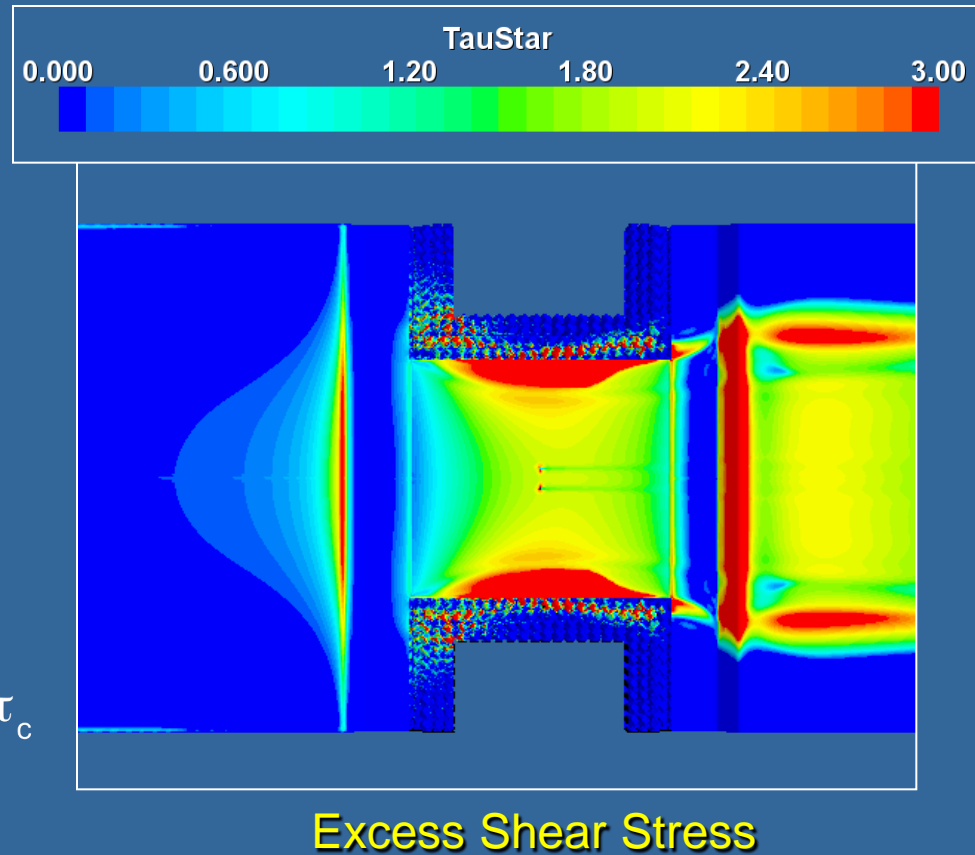
Case2

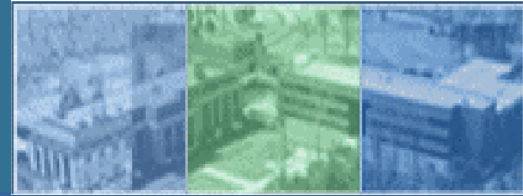


Flow

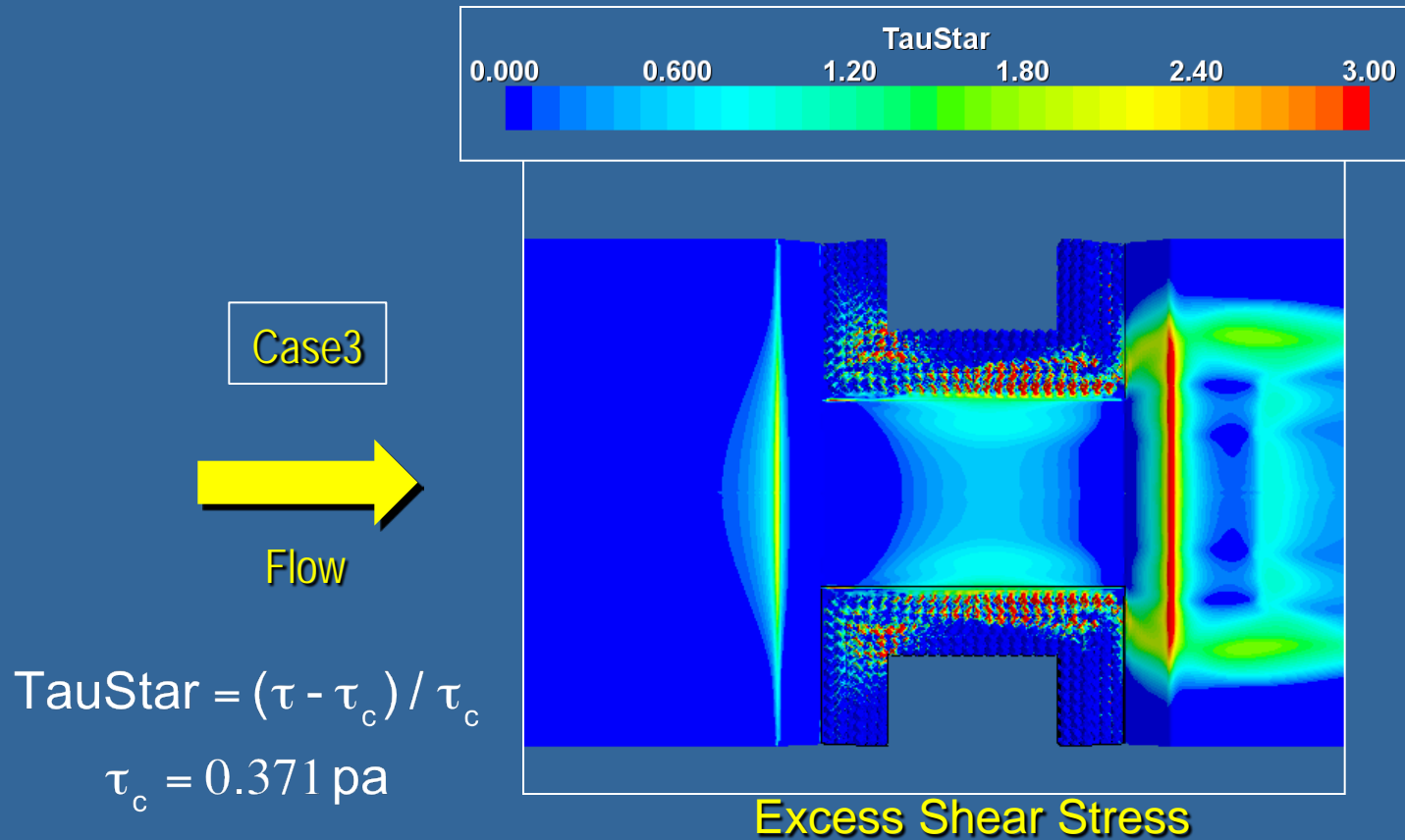
$$\text{TauStar} = (\tau - \tau_c) / \tau_c$$

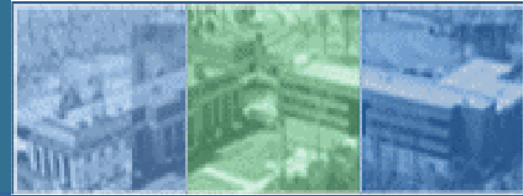
$$\tau_c = 0.371 \text{ pa}$$





CFD Simulation for Riprap around Abutment





CFD Simulation for Riprap around Abutment

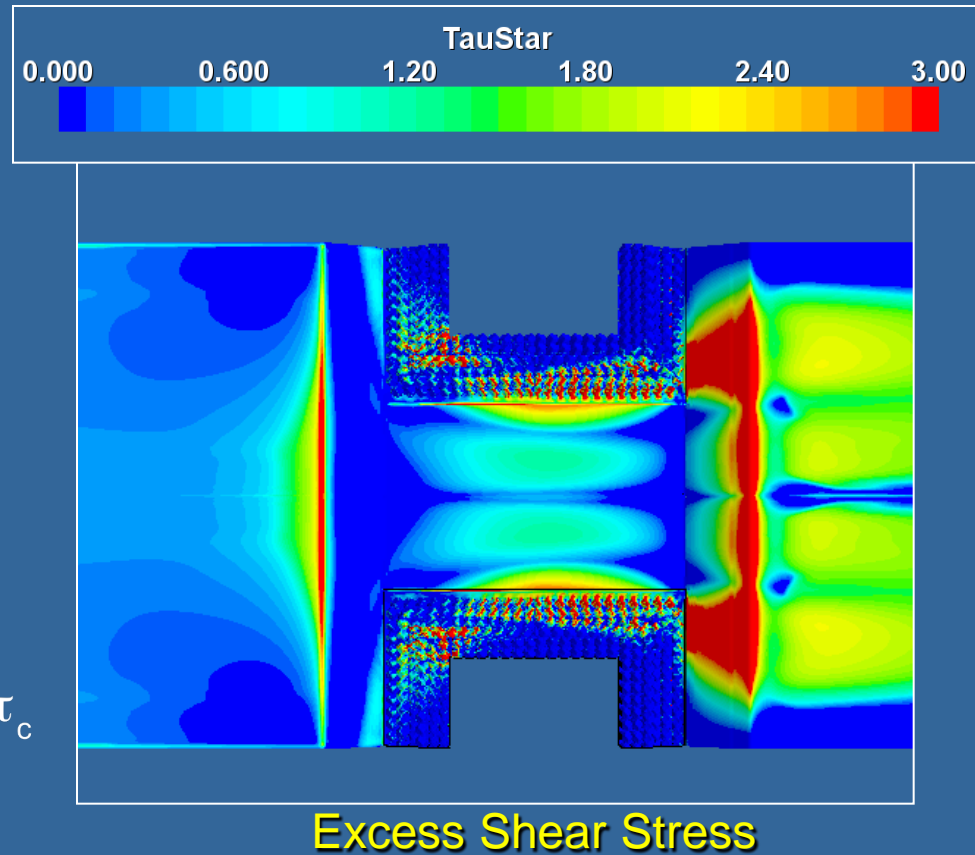
Case4

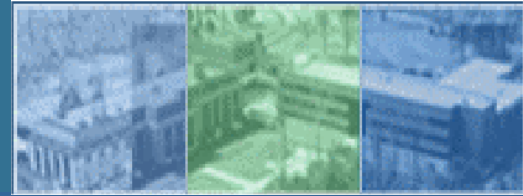


Flow

$$\text{TauStar} = (\tau - \tau_c) / \tau_c$$

$$\tau_c = 0.371 \text{ pa}$$



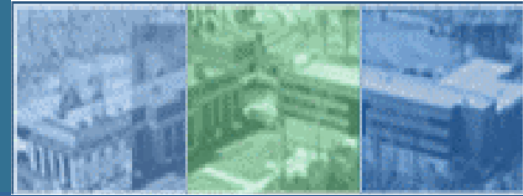


Buried Riprap Installation



Riprap apron placed at same elev. of
Contraction Scour + Long Term Degradation

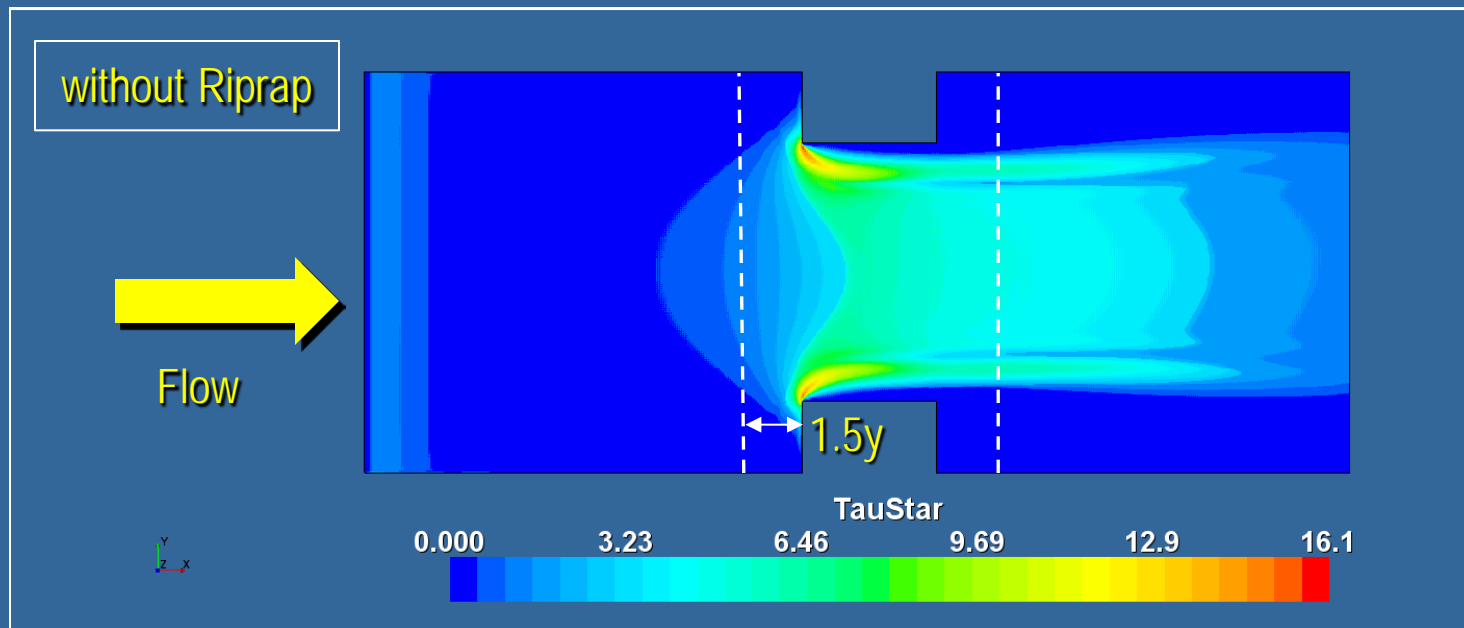


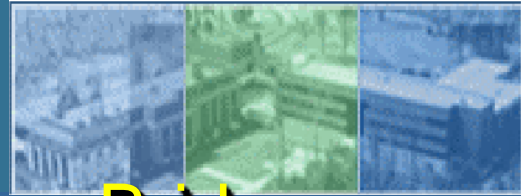


Upstream and Downstream Riprap Apron Extent

$$\text{TauStar} = (\tau - \tau_c) / \tau_c$$

$$\tau_c = 0.371 \text{ pa}$$





Buried Riprap Installation for Narrow Bridge Openings



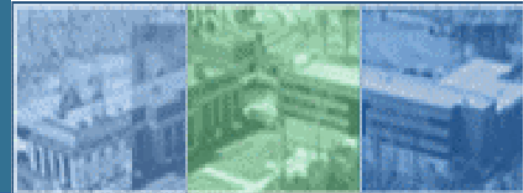
Excavation



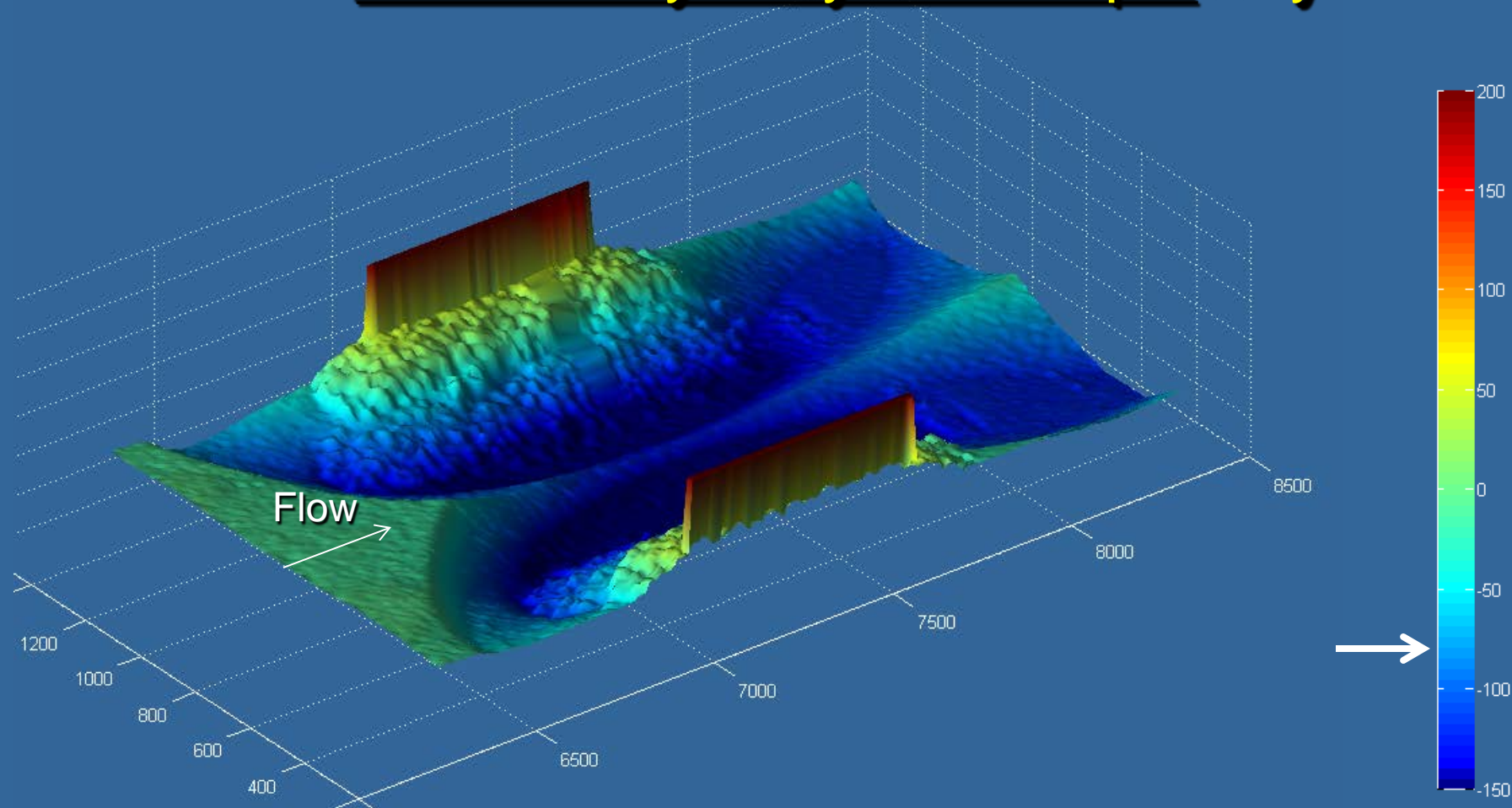
Riprap Placement

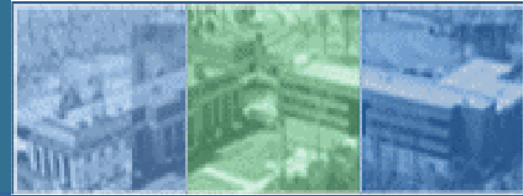
Riprap apron extent W_1 into the Main Channel depends on Bank Slope for a smooth transition



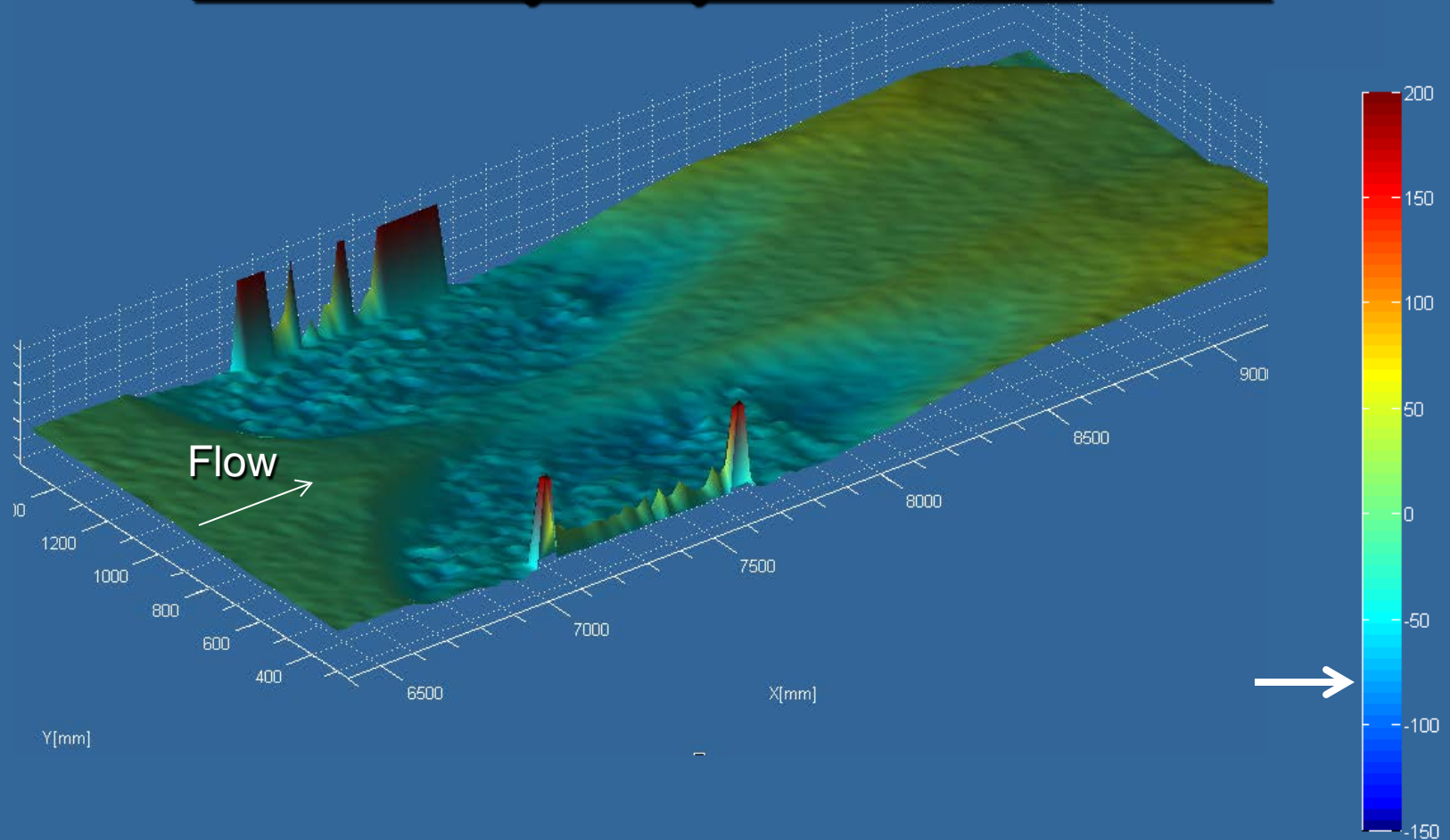


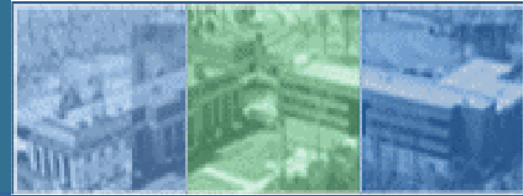
Scour Bathymetry Side Slope W=y



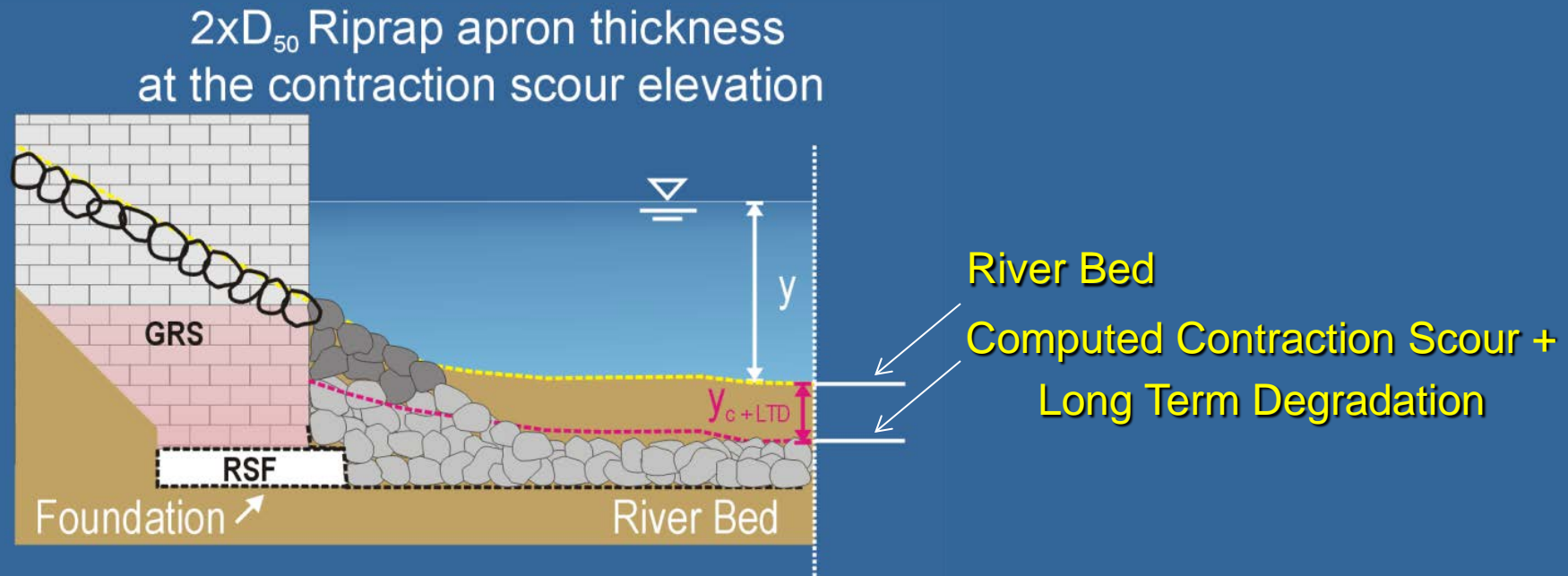


Scour Bathymetry Buried Installation





Proposed Installation: Buried Riprap

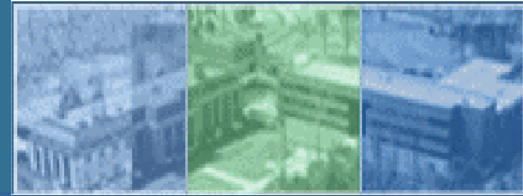


Riprap apron placed at same elev. of
Contraction Scour + Long Term Degradation





TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

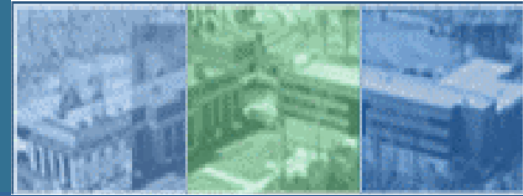


THANK YOU !



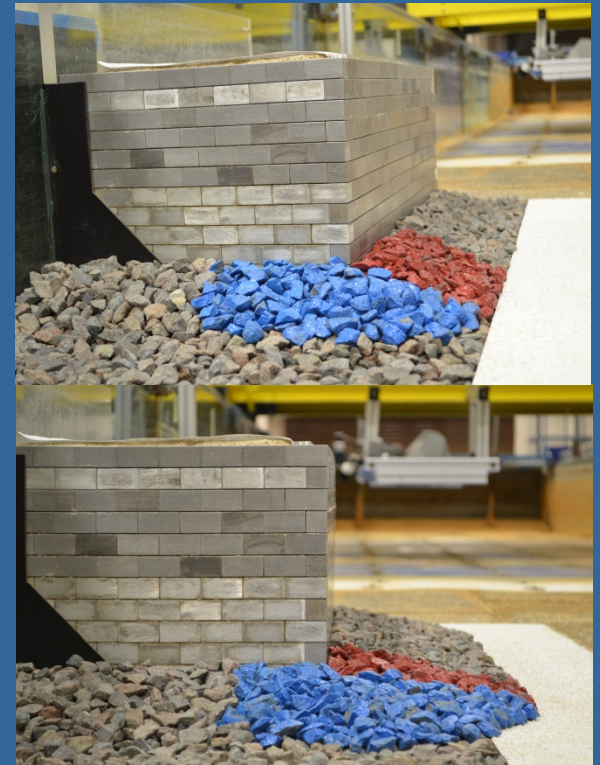
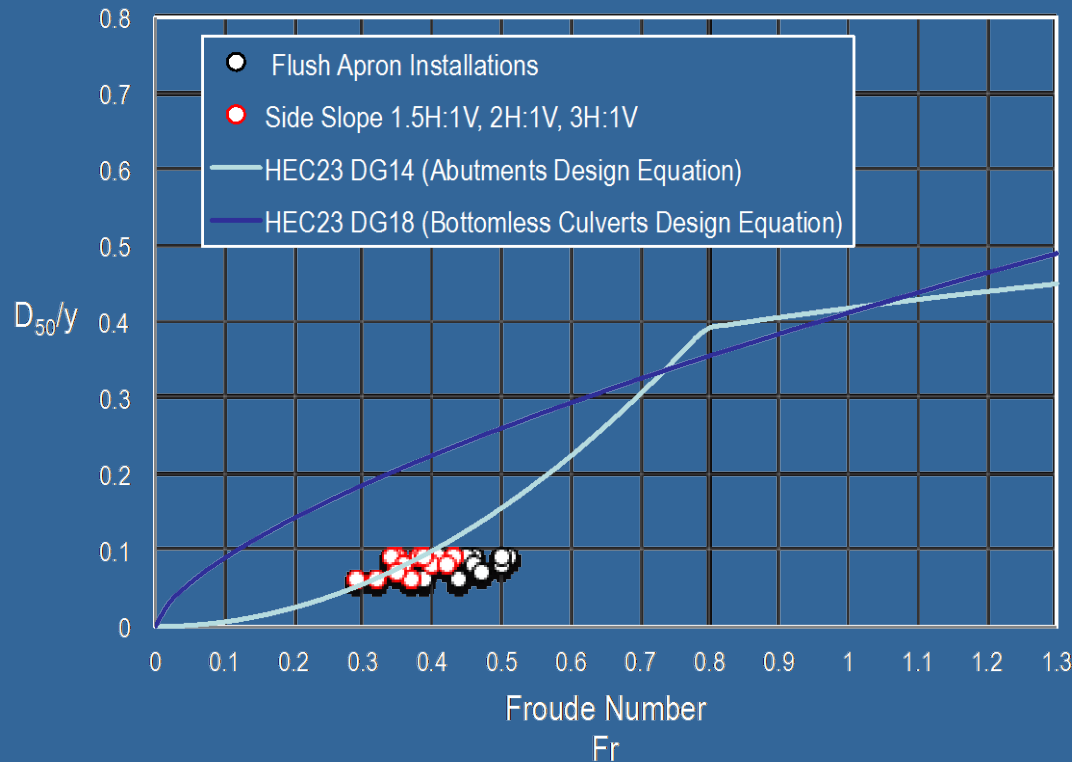
U.S. Department of Transportation
Federal Highway Administration

GENEX
SYSTEMS



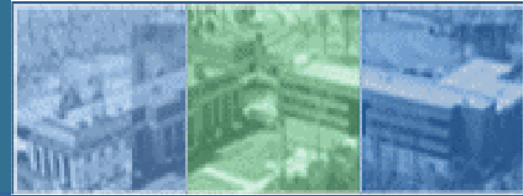
Riprap Size Stability Experiments: Shear Failure

- HEC-23 Rock Sizing Equations are based on experiments using flush riprap mattress only.



Side Slope 3H:1V, 2H:1V and 1.5H:1V



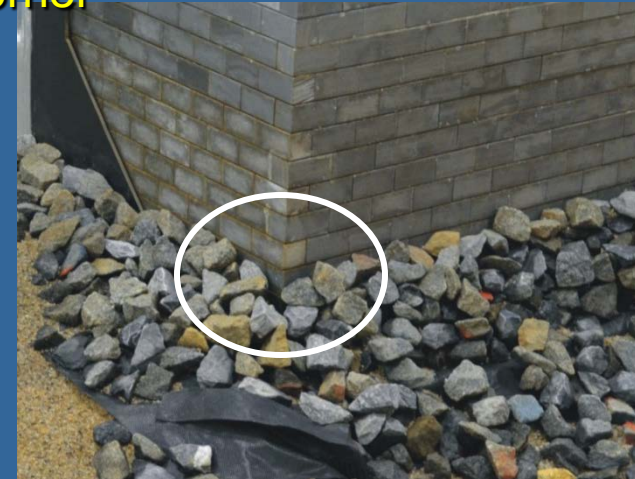


Side Slope Installation: Failure Mechanism

Riprap Edge Failure and Translational Slide



GRS Abutment upstream corner



Riprap rock is removed
From the immediate vicinity
of the abutment toe

