INVESTIGATION OF EROSION RATES OF FIELD SAMPLES USING FDOT'S ENHANCED SEDIMENT EROSION RATE FLUME (SERF)

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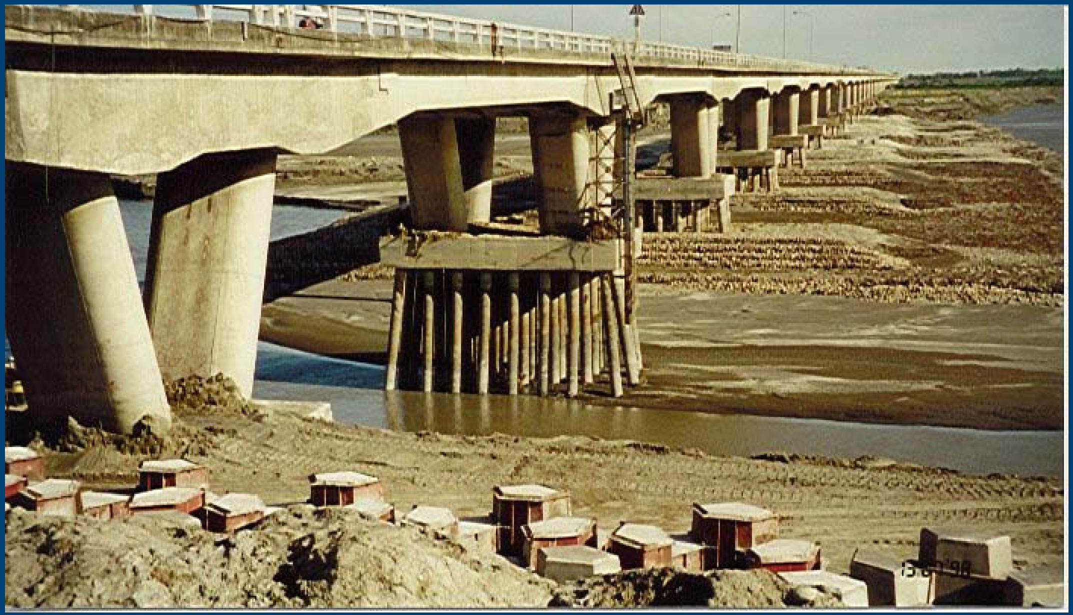
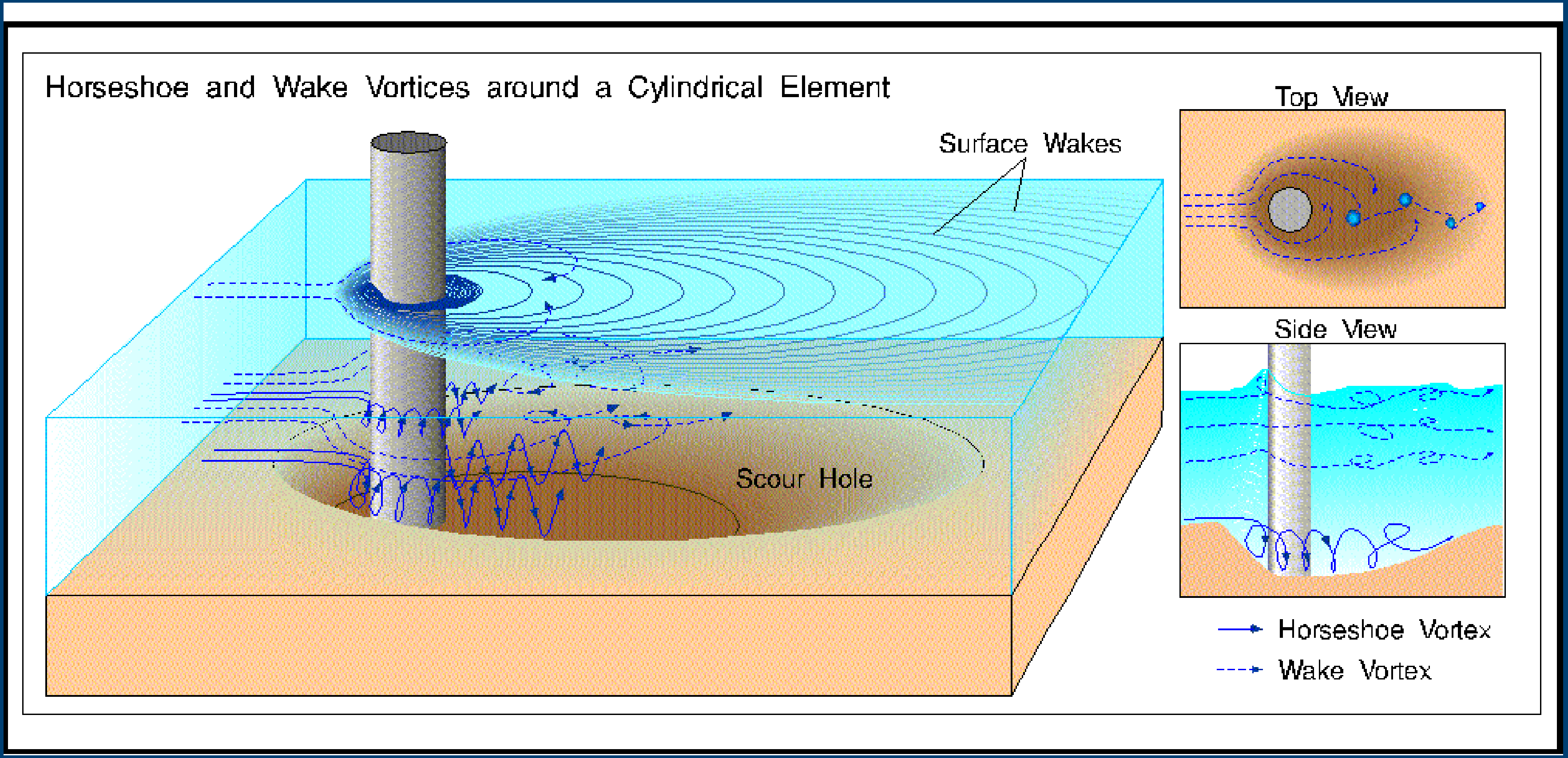
Bridge Scour



Bridge Scour Photograph

- 600,000 US Bridges; 200,000 are “Scour Critical”
- Causes 60% of US Bridge Failures
- Costs $50 Million Annually
- Design Codes Currently Offer Alternative Method for Cohesive Soil Design

Local Scour



Local Scour Mechanism

Computing Cohesive Scour

$$\tau_{max} = 0.094\rho U^2 \left[\frac{1}{logRe} - \frac{1}{10}\right]$$

$$z_{max} = z_{sand}$$

$$z = \frac{t}{\frac{1}{\dot{z}} + \frac{t}{z_{max}}}$$

$$Re = \frac{UD}{\nu}$$

$$\dot{z} = f(\tau) = M(\tau_b - \tau_c)$$

τ_{max} = Maximum shear stress

U = Water velocity in field

Re = Reynolds Number in field

z_{max} = Maximum scour depth

t = Time

$\dot{z}$ = Erosion rate

ν = Viscosity of water

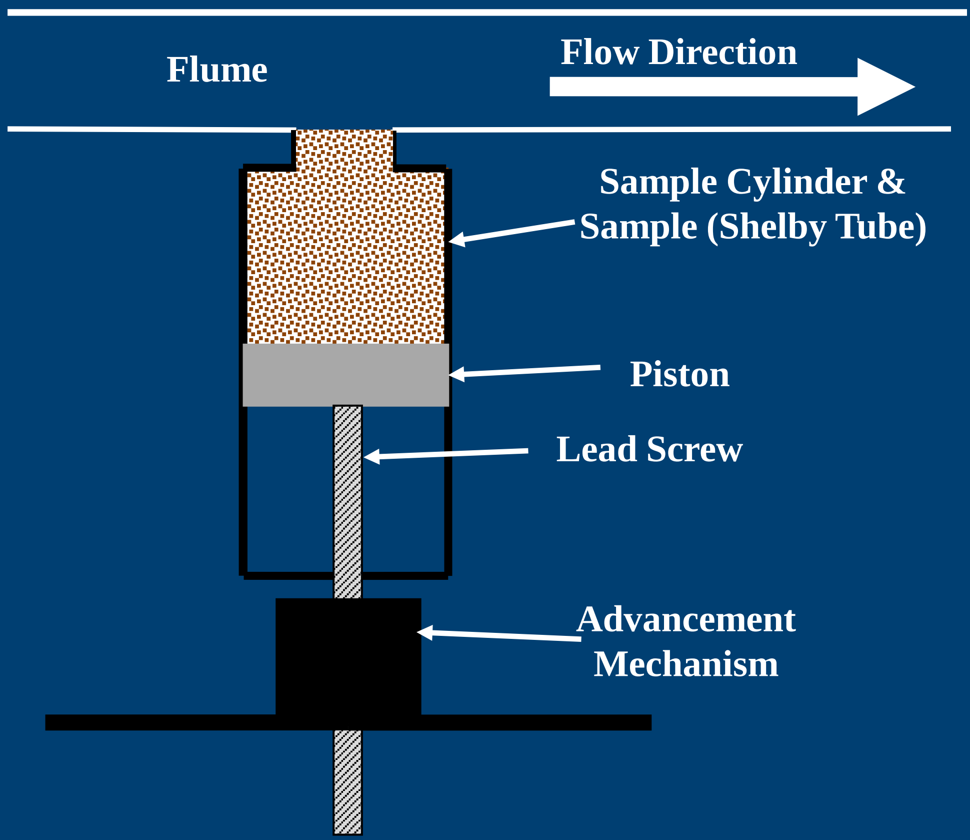
D = Diameter of pier

M = Material-specific erosion constant

τ_b = Bed shear stress

τ_b = Critical shear stress

Flume-Style Erosion Rate Testing Devices



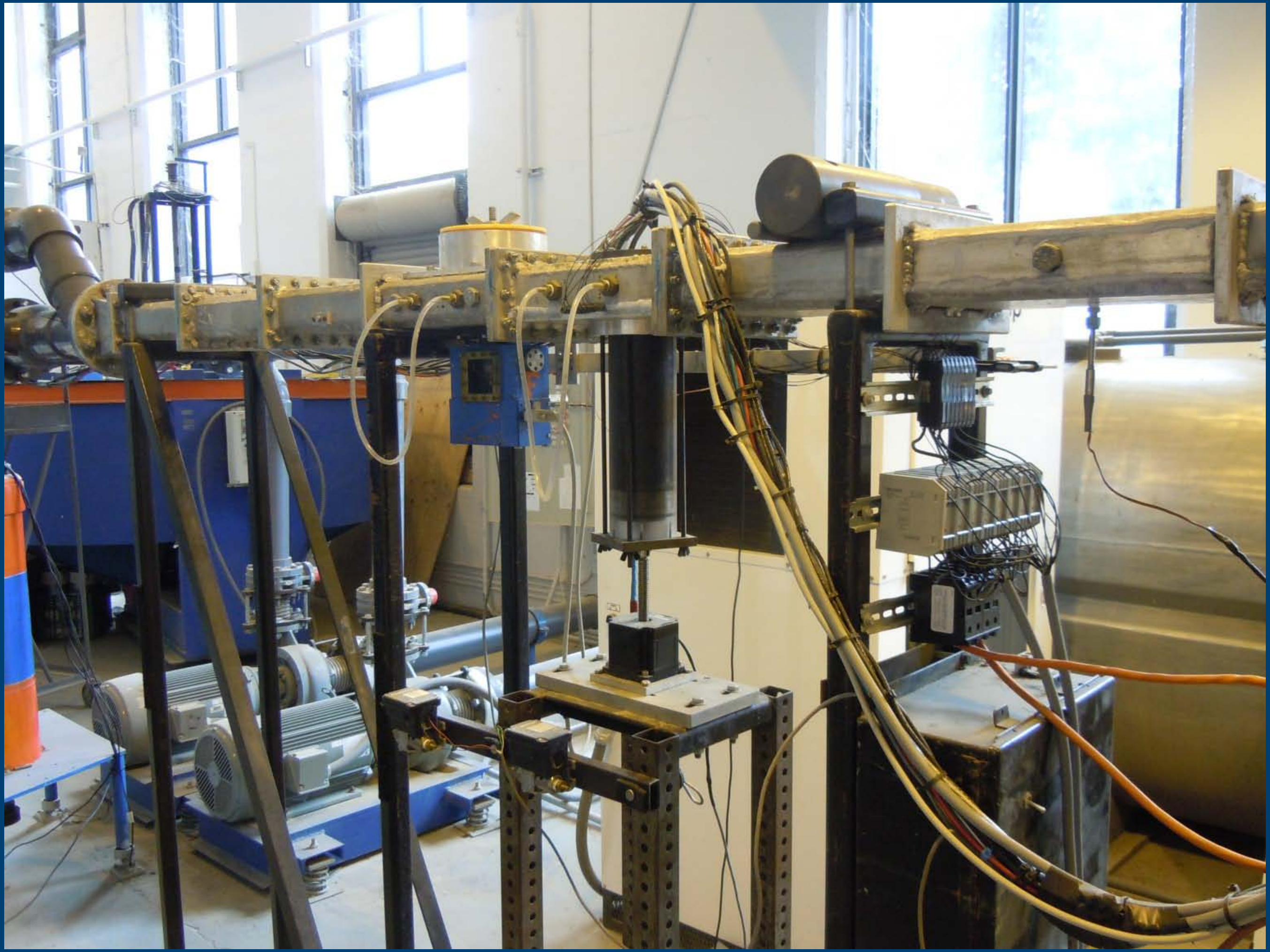
SERF Schematic

New SERF – Bird's Eye View

SERF (Looking North)

SERF (Looking South)

New SERF – Close up

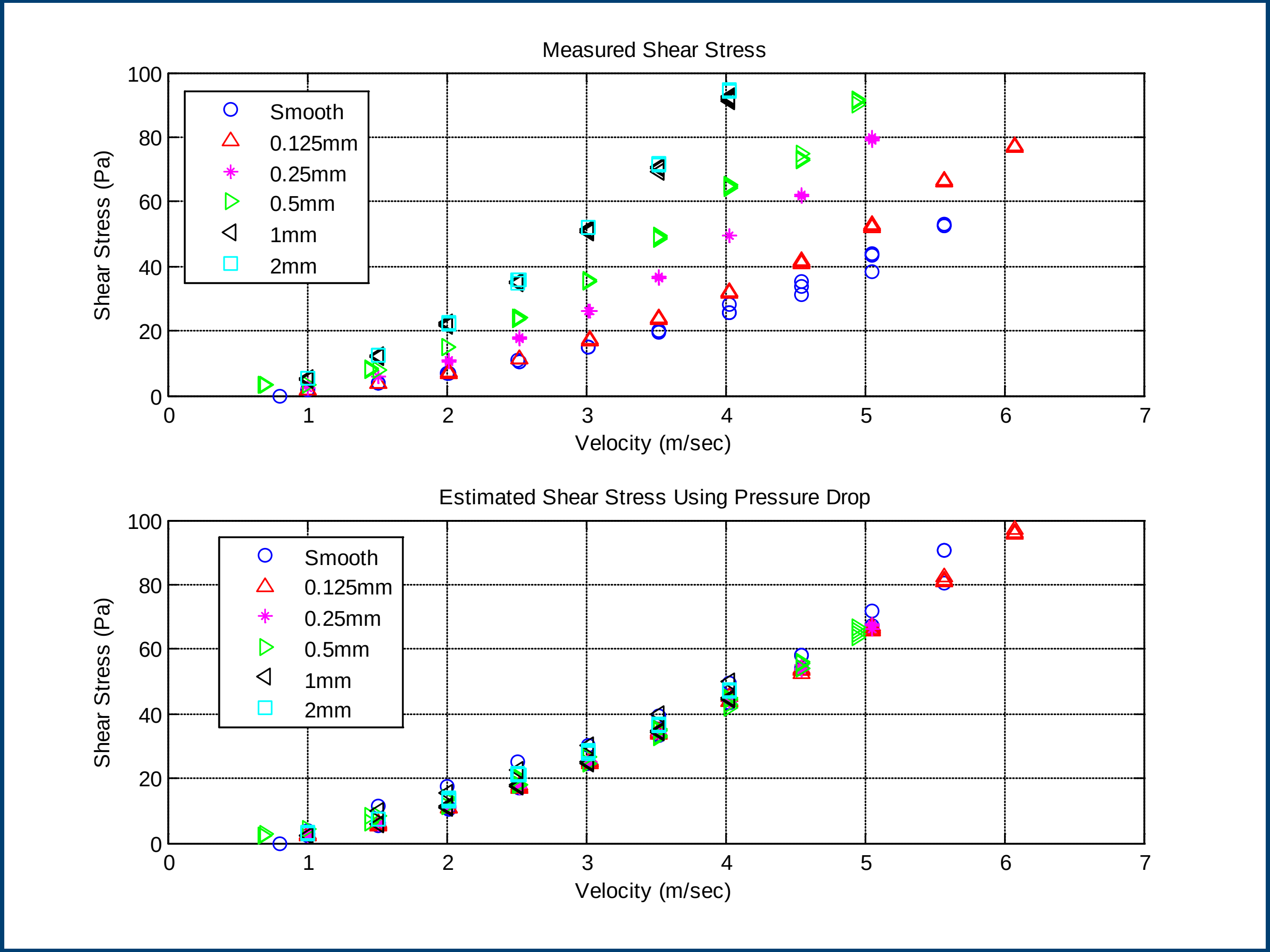


Photograph of New SERF

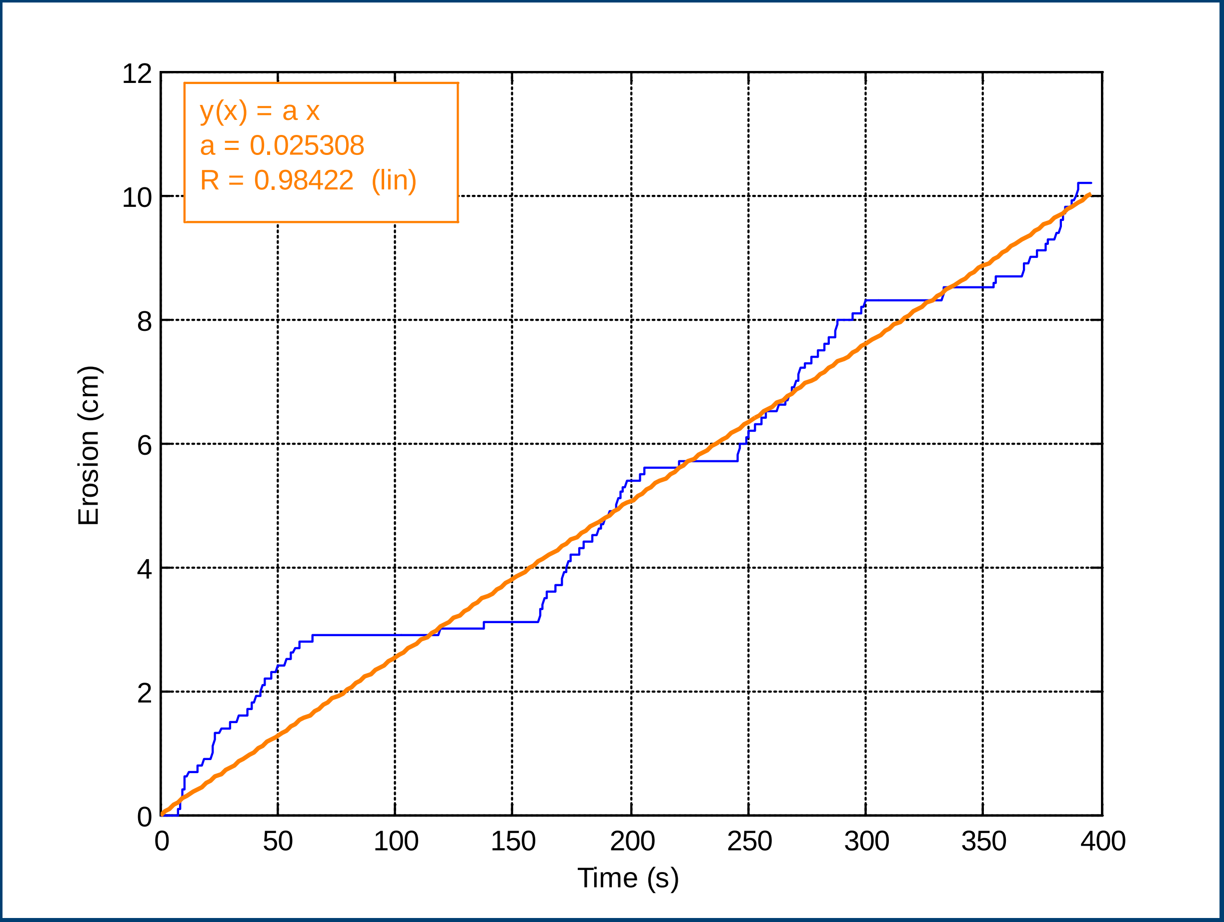
Questions for Piston-Style Erosion Tests

- How to resolve shear stress in such an instrument during an erosion test?
- Is "average" shear stress indicative of actual stress conditions in nature?
- How accurate is it to assign an average "Erosion Rate" for a given soil specimen?

Previous Data – Shear Stress

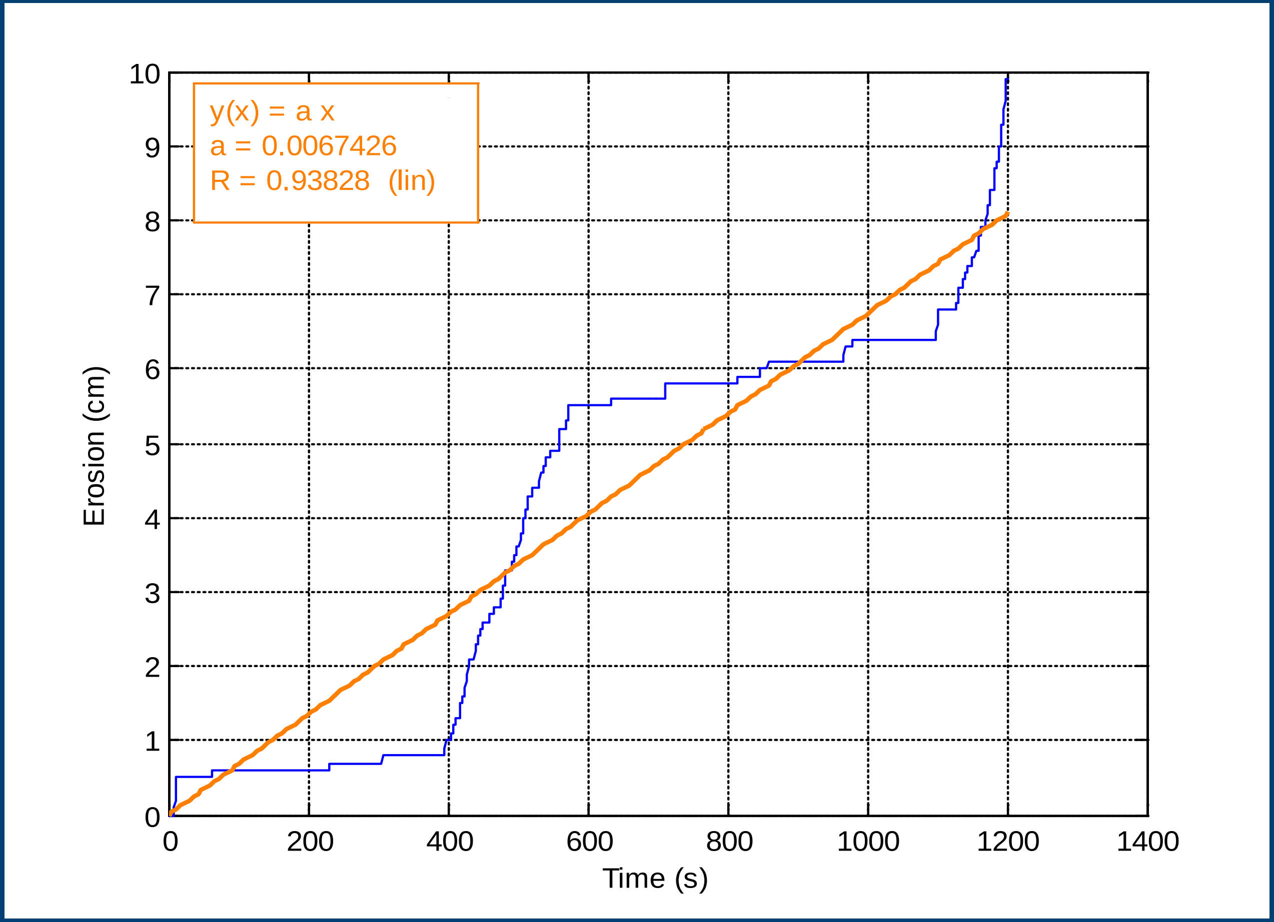


SERF Results – Laboratory Samples



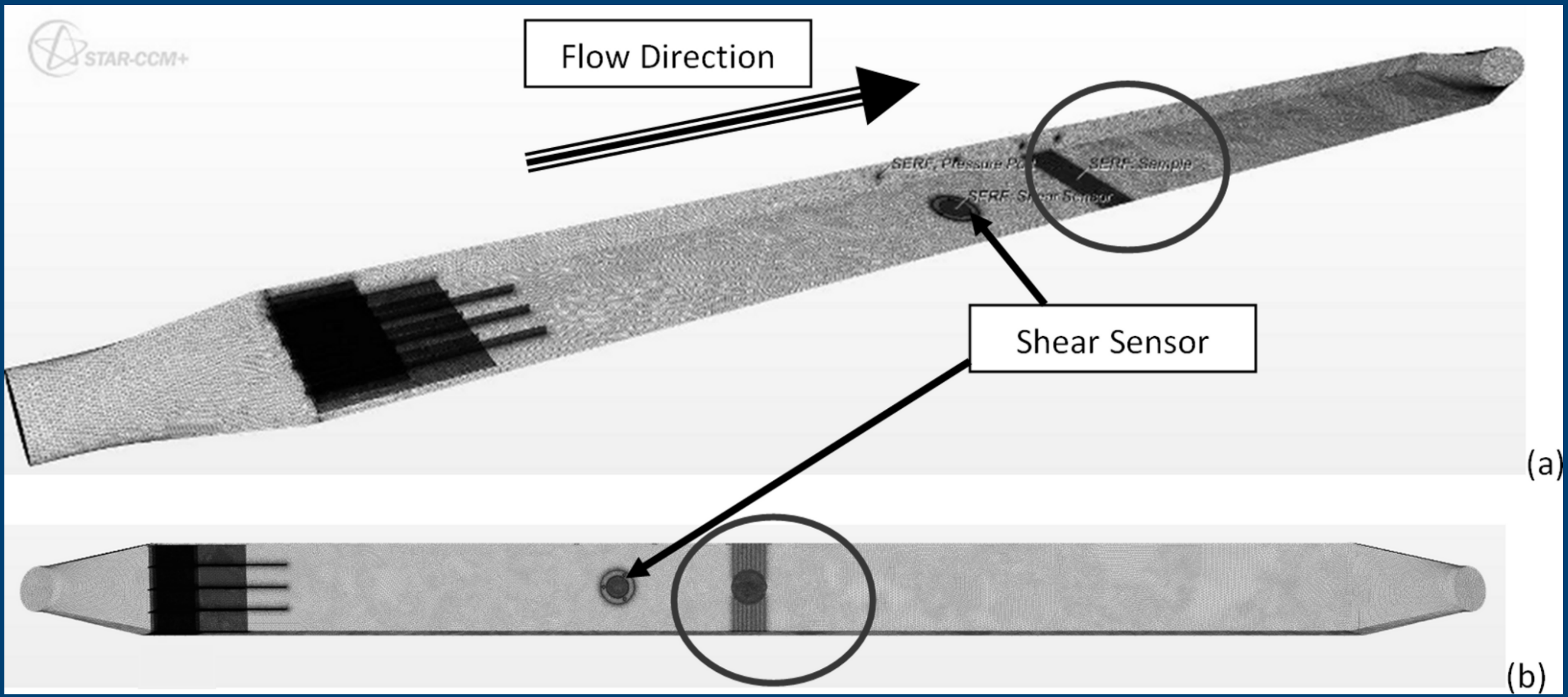
Erosion vs. Time Data for 25:75 Clay-Sand Mixture at 2.0 m/s (Re = 1.62×10^5) Using 4 Lifts

SERF Results – Laboratory Samples



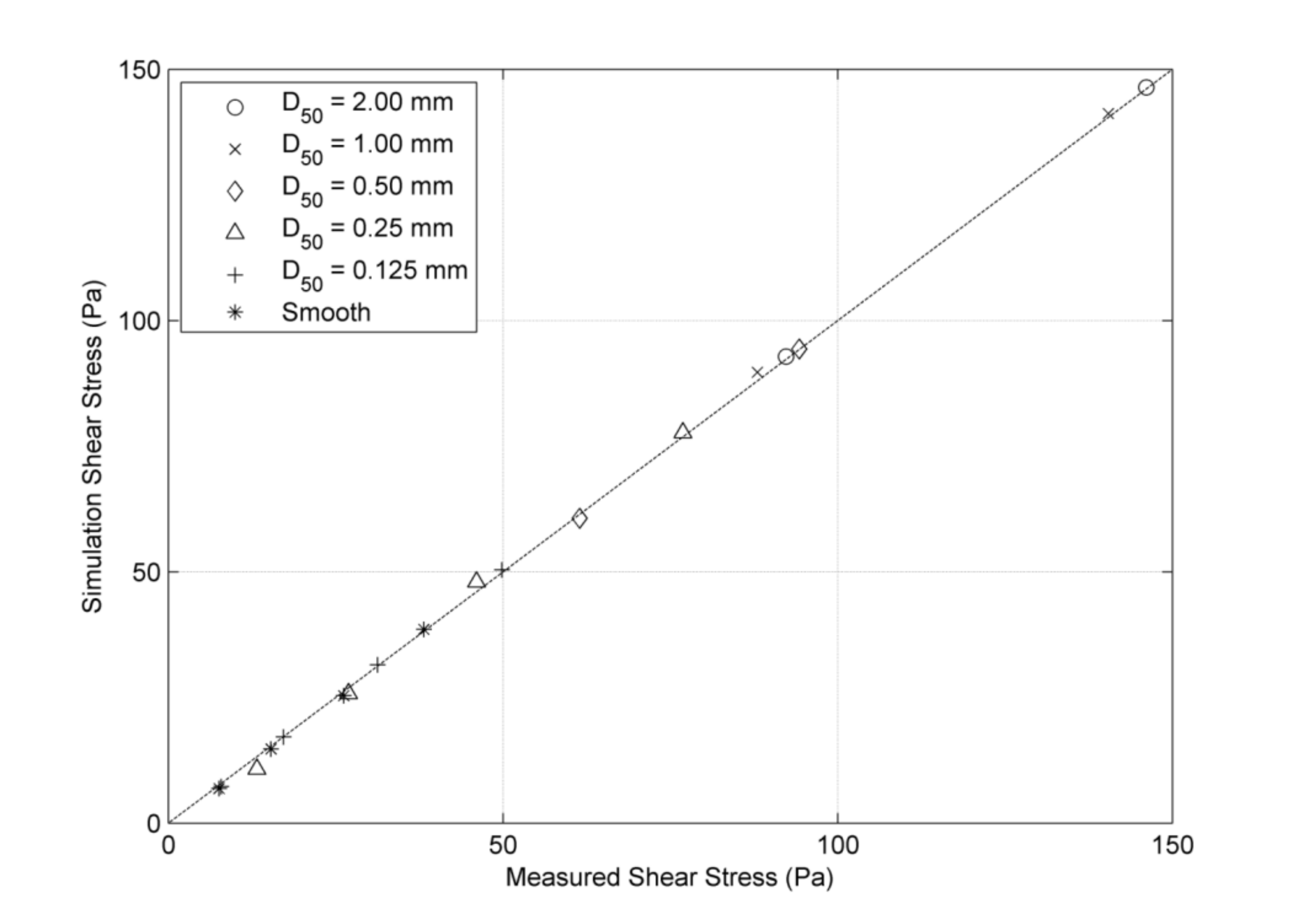
Erosion vs. Time Data for 25:75 Clay-Sand Mixture at 2.0 m/s (Re = 1.62×10^5) Using 2 Lifts

Shear Stress – CFD Modeling



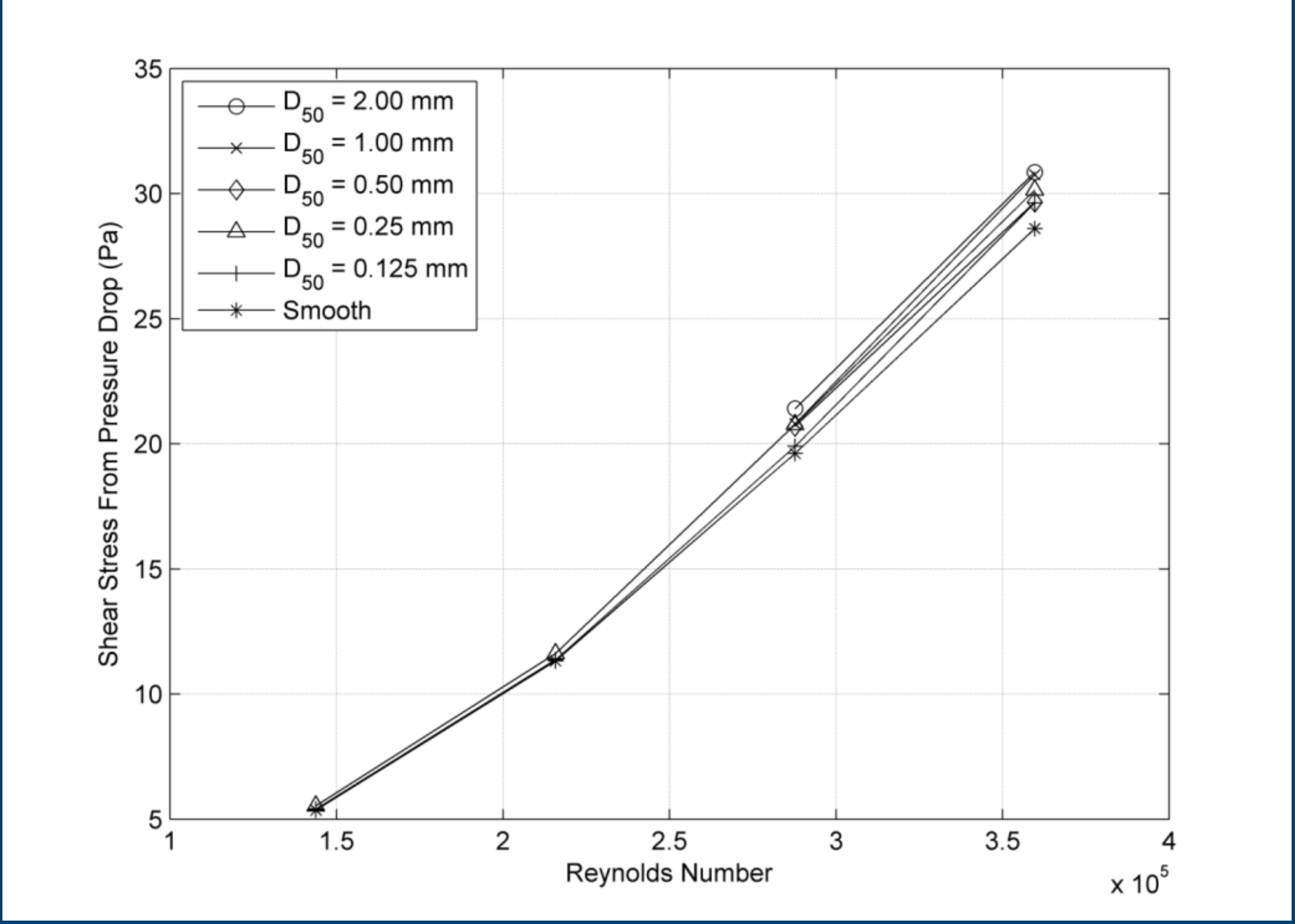
SERF Mesh

CFD Data Matching



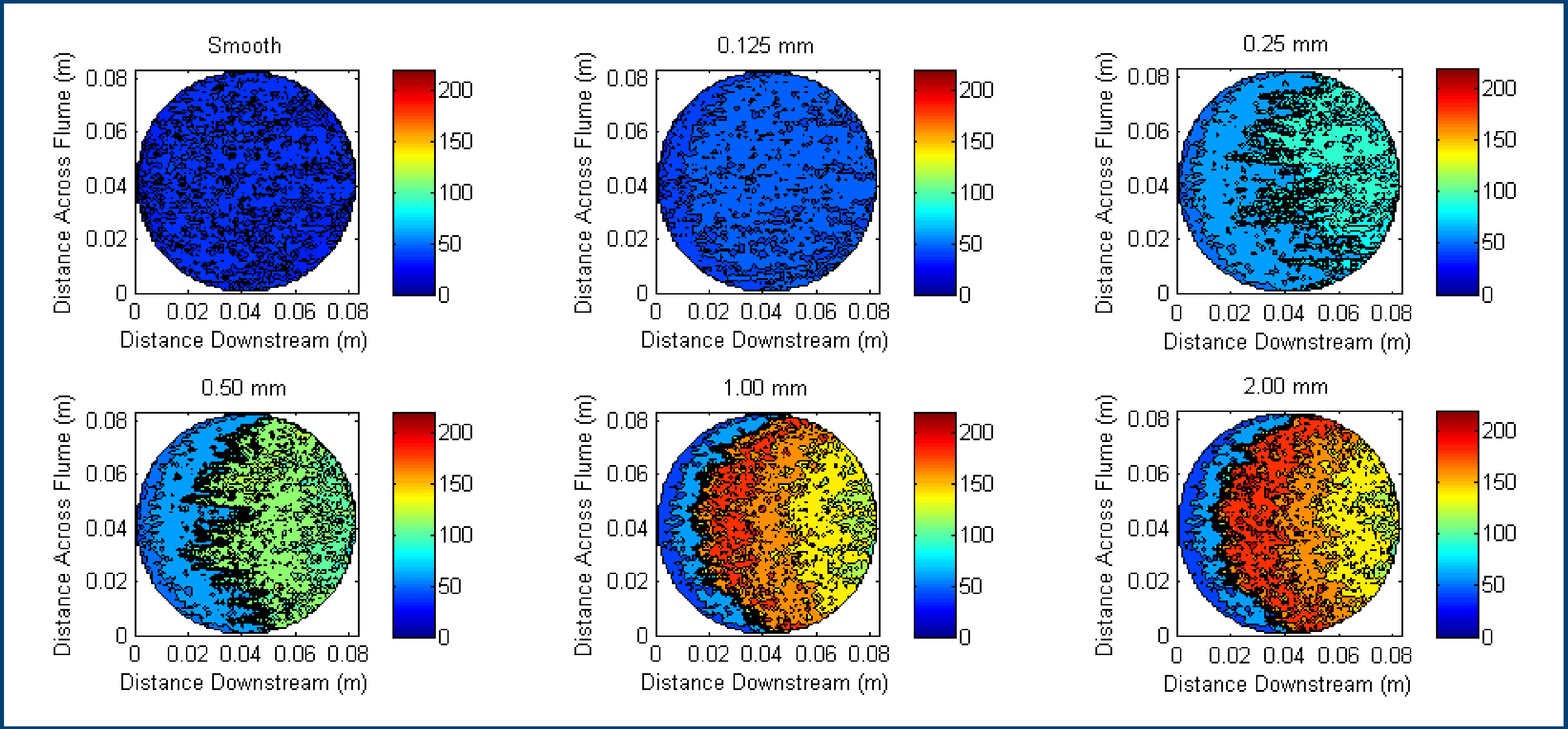
Matched Data Results for Total Disc Shear Stress

CFD Shear Stress Using Pressure Drop



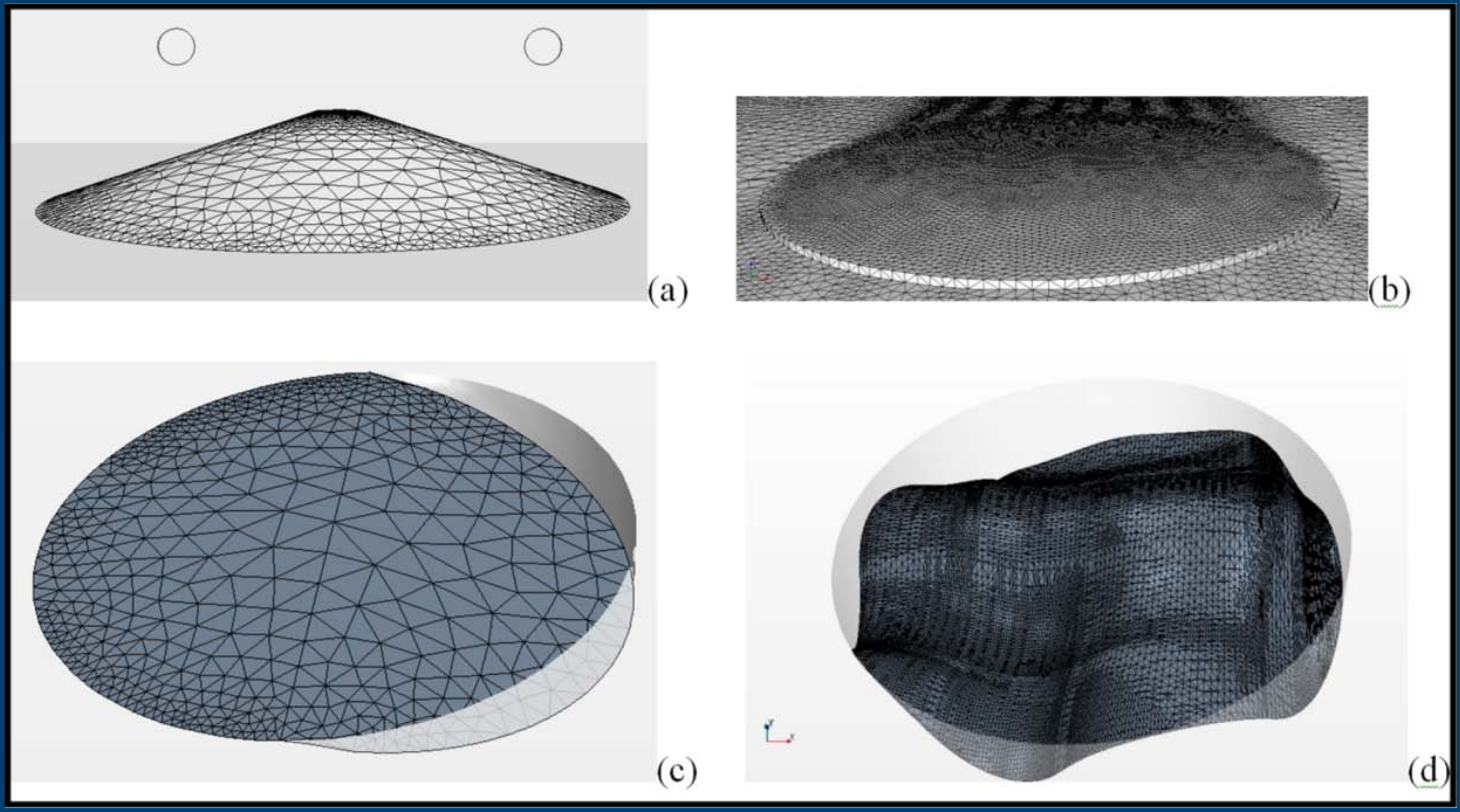
Shear Stress Using Modeled Pressure Drop Data

CFD Shear Stress Distribution



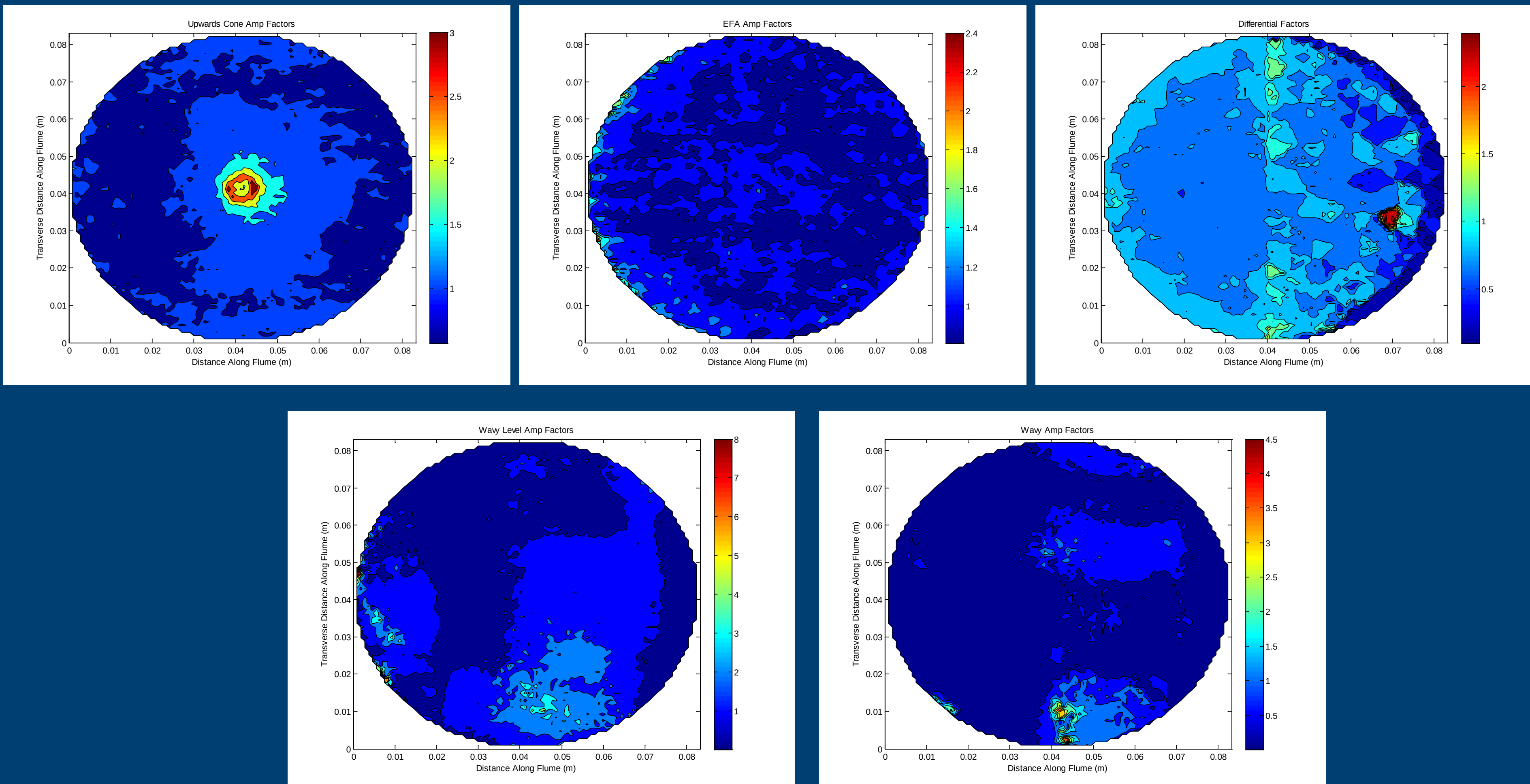
Disc Shear Stress at 5.0 m/s for Various Roughnesses

Complex Bed Configurations



Modeled Complex Bed Configurations

Amplification Factors – Upward Cone



Amplification Factors (From Top-Left: Upward Cone, EFA, Differential, Wavy, Wavy-Level)

Conclusions (Shear Stress)

- Pressure drop method is a poor estimator of wall shear stress during an erosion test.
- Relatively small changes in geometry may have large effects on localized shear stress.
- An increase in roughness appears to significantly increase localized shear stresses.
- During testing, minimum sample elevation should be kept flush with flume bottom, and assume a smooth wall

Conclusions Shear Stress (Continued)

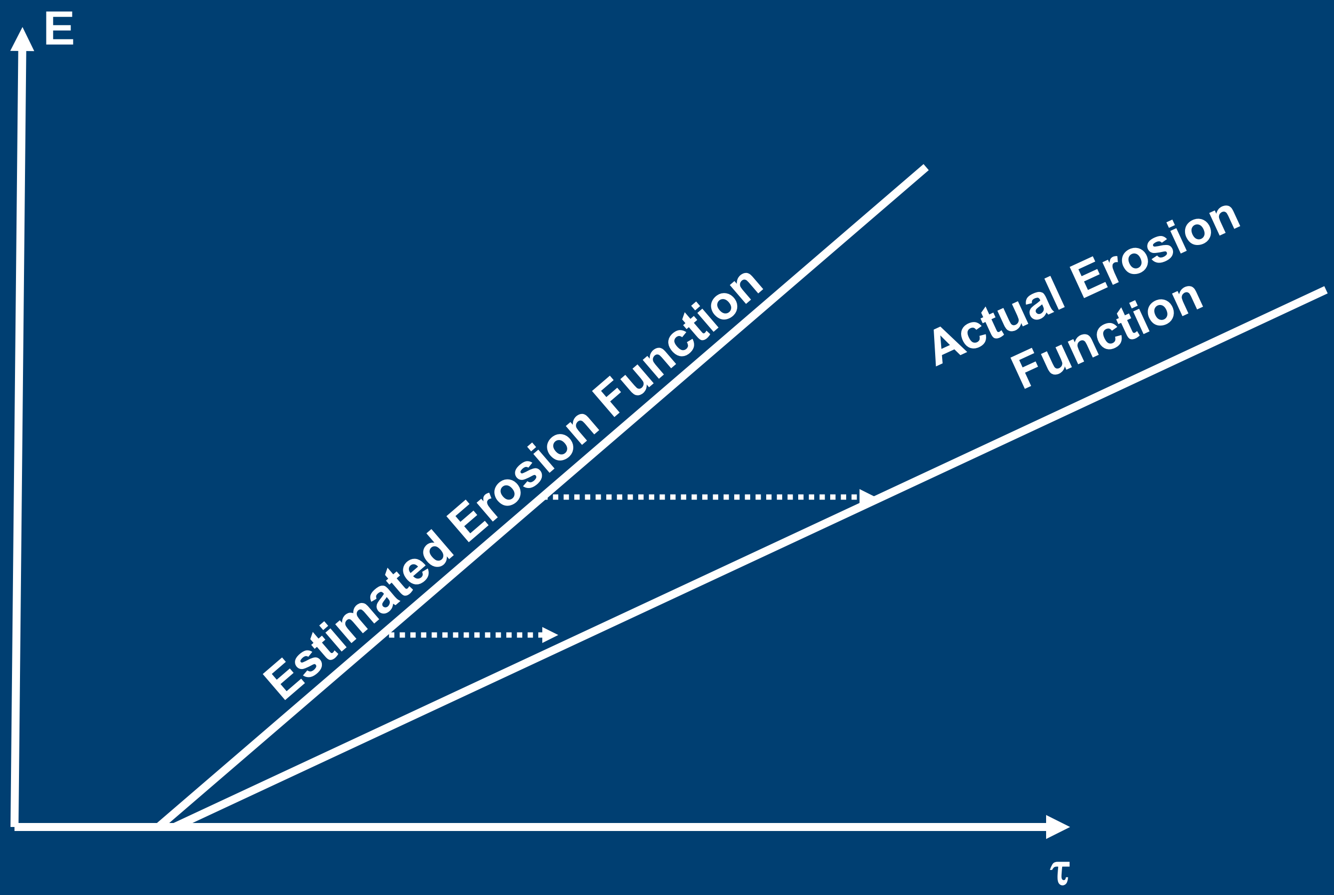
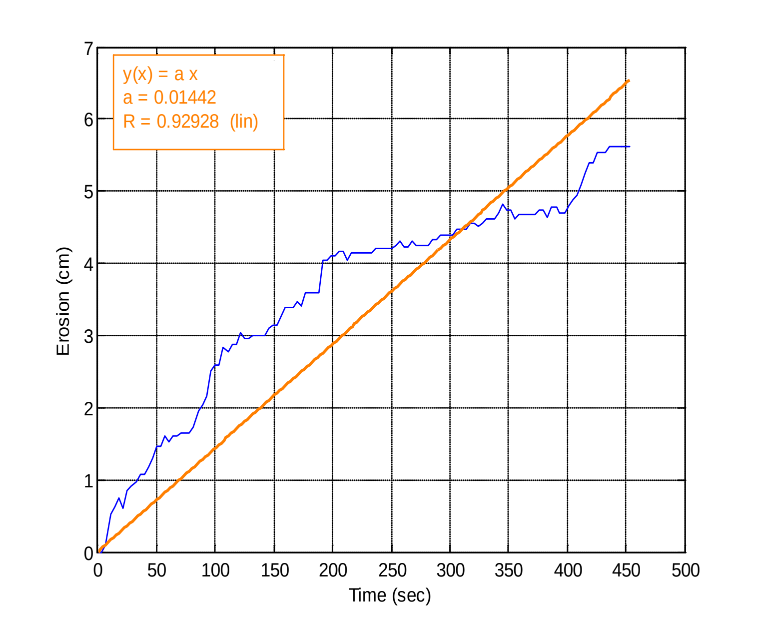
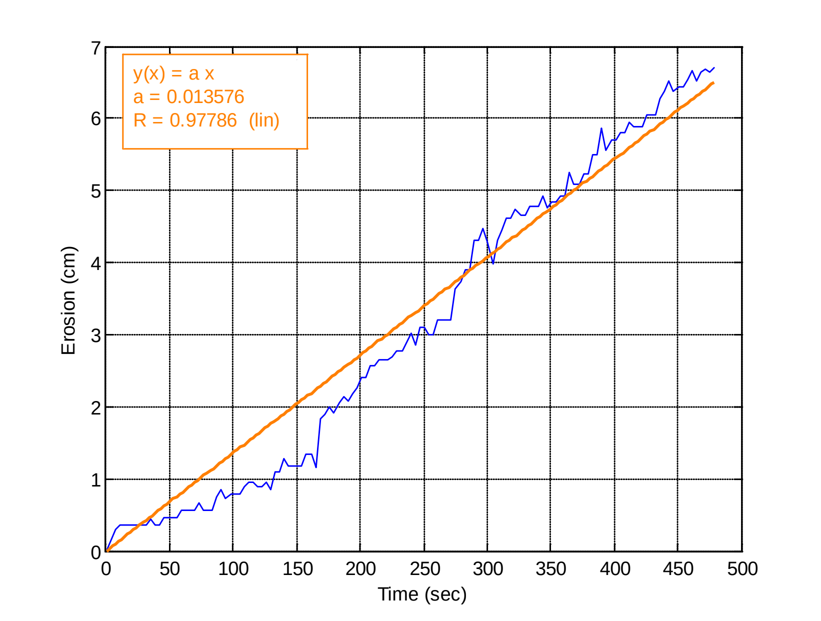


Illustration of Conservative Design Recommendations

Selected Sample Results – Erosion Rates

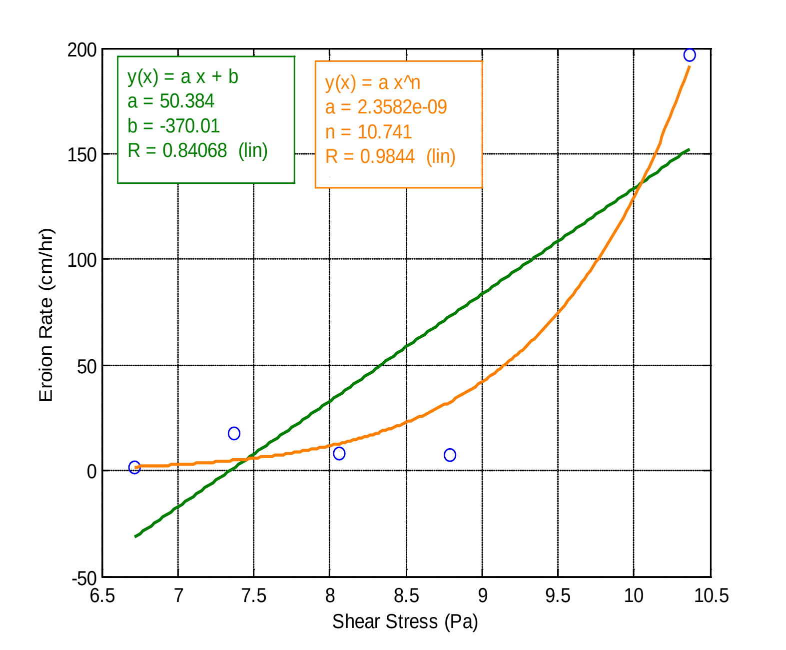


Erosion versus time for Anderson St. Specimen

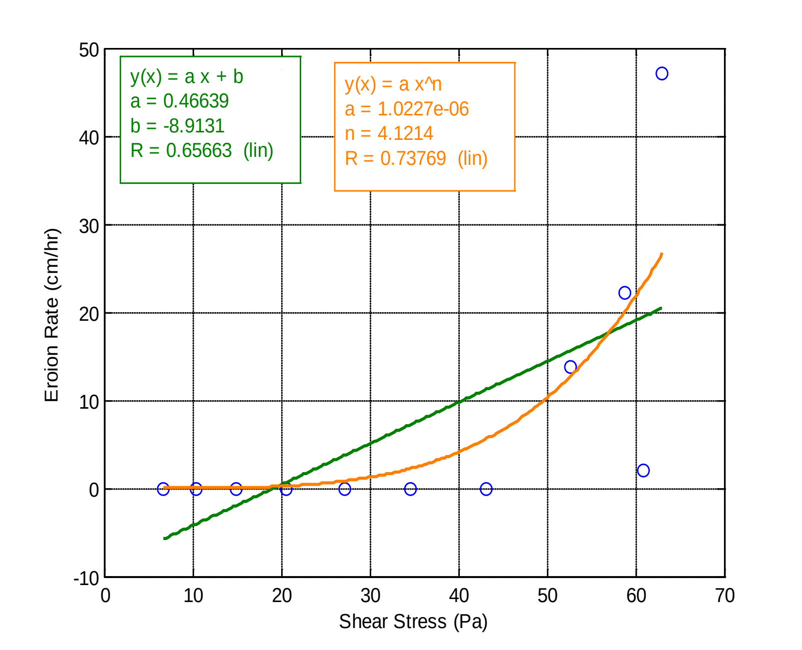


Erosion versus time for River Run at Gum Creek Specimen

Selected Sample Results – Erosion Rates



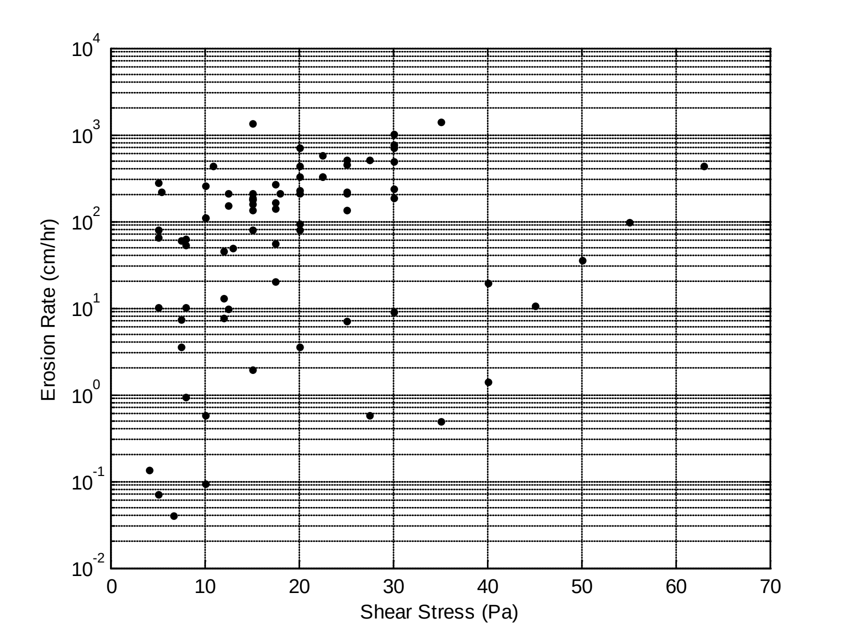
Erosion versus time for Jewfish Creek Specimen 1

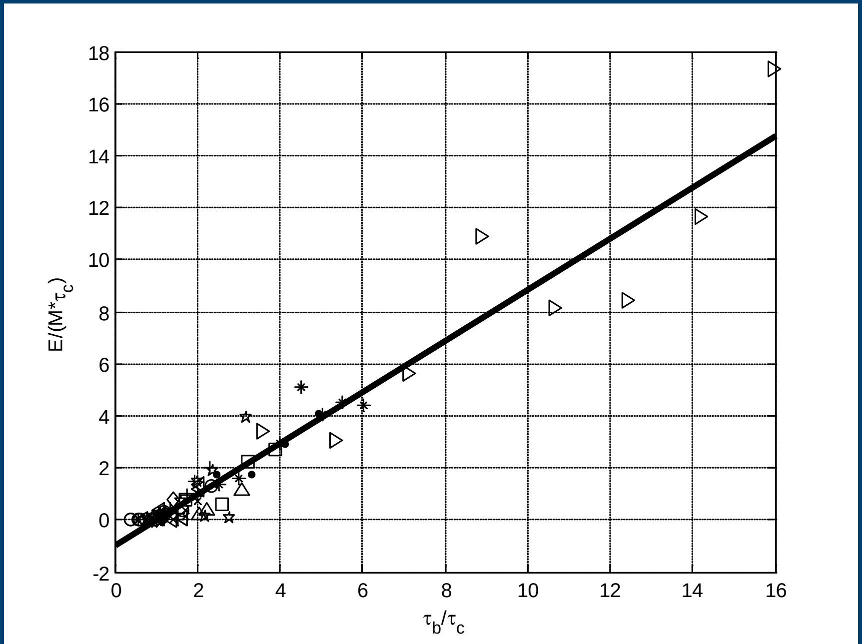


Erosion versus time for Jewfish Creek Specimen 2

$$E = M(\tau_b - \tau_c)$$

Selected Sample Results – Erosion Rates





- $\mu_M \sim 44; \sigma_M \sim 71$
- $\mu_{\tau_c} \sim 11; \sigma_{\tau_c} \sim 12$

Conclusions – Erosion Rates

- Field samples very much mimic synthetic samples in that much depth variability was shown
- Much variability between erosion rates that presumably “should” be the same at the same depth
- Sampling pattern matters!

Questions?