

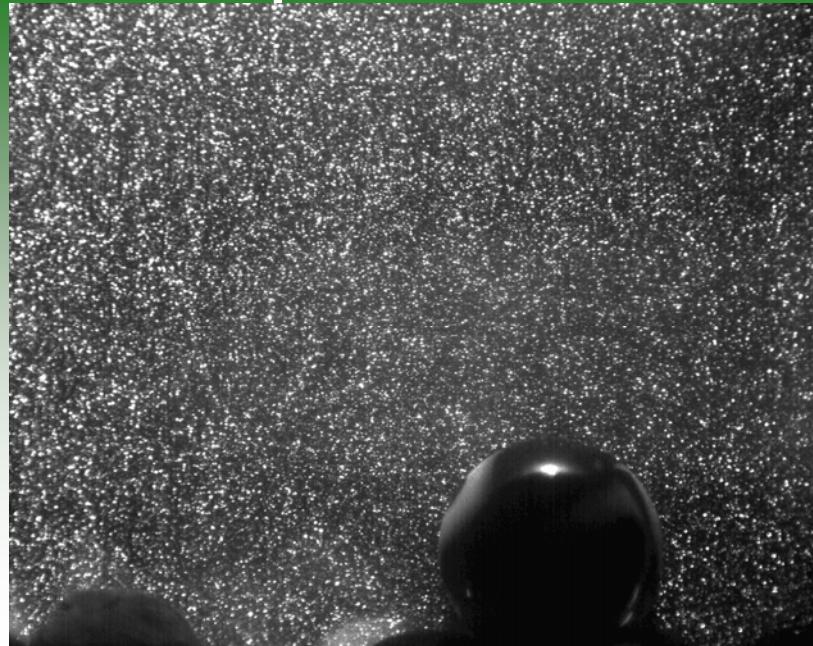
Sedimentation Engineering... Incipient Motion and Bedforms

Pierre Y. Julien

Professor of Civil and Environmental Engineering
Colorado State University, Fort Collins, CO 80523
pierre@engr.colostate.edu

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UiTM, Shah Alam, Malaysia

Incipient Motion



Shields Parameter

- Ratio of Hydrodynamic Forces to Submerged Weight

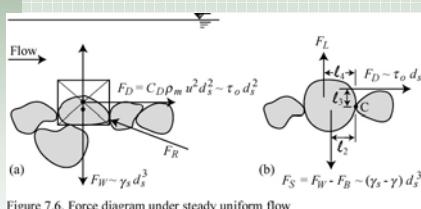


Figure 7.6. Force diagram under steady uniform flow

$$\tau_* = \frac{\tau_o}{(\gamma_s - \gamma)d_s} = \frac{\rho_m u_*^2}{(\gamma_s - \gamma)d_s}$$

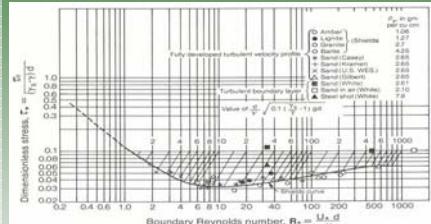


Figure 7.7. Shields diagram for granular material

Beginning of Motion

- Critical Shields Parameter(τ_{*c})
 - beginning of motion ($\tau_o = \tau_c$)

$$\tau_{*c} = \frac{\tau_c}{(\gamma_s - \gamma)d_s}$$

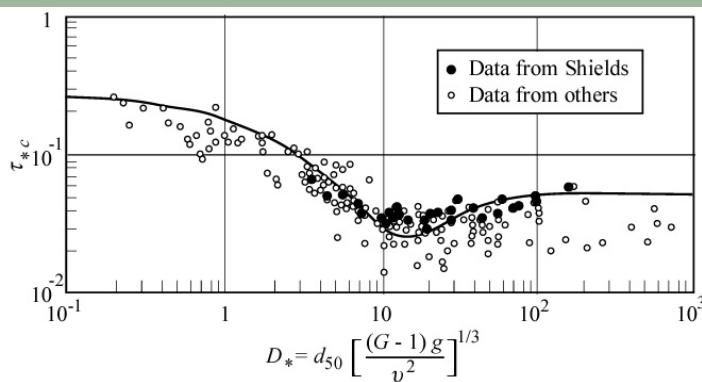


Figure 7.8. Modified Shields diagram

Calculating Critical Shear Stress

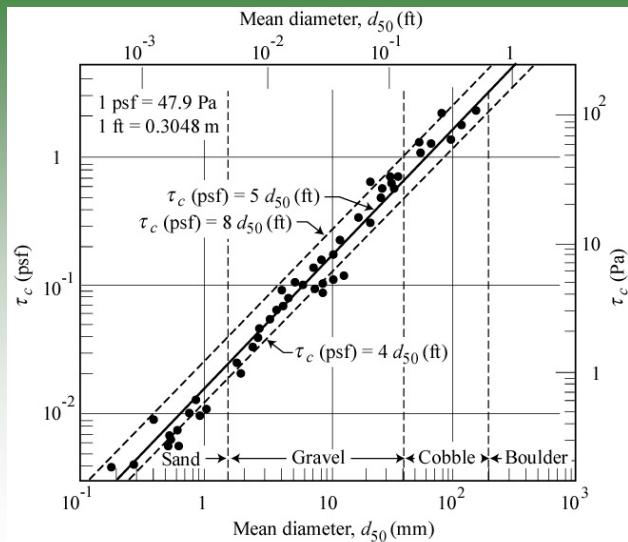


Figure 7.9. Critical shear stress on a horizontal surface

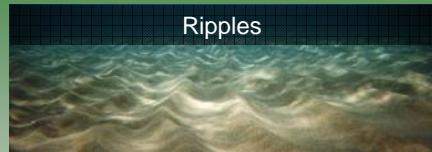
Bedforms and Resistance to Flow

What are bedforms?

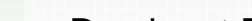
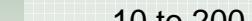
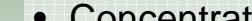
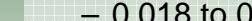
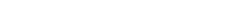
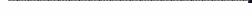
Initiation of Bedforms on a flat bed



Ripples



Dunes



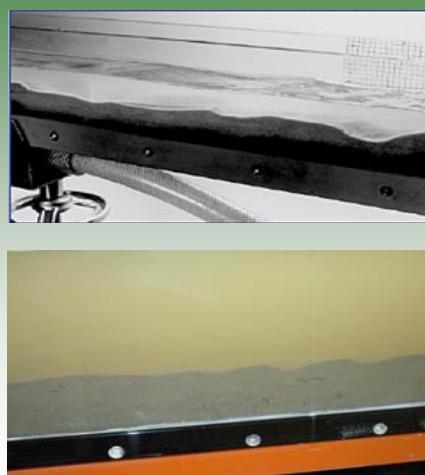
Lower Regime - Dunes

- Coarser Grain Diameter
 - $d_{50} < 2 \text{ mm}$
- Manning n
 - 0.02 to 0.04
- Concentration
 - 200 to 3000 mg/L
- Large Features
 - Up to tens of meters in height
- Dominant Roughness
 - Form
- Field Characteristic
 - Boils on the water surface



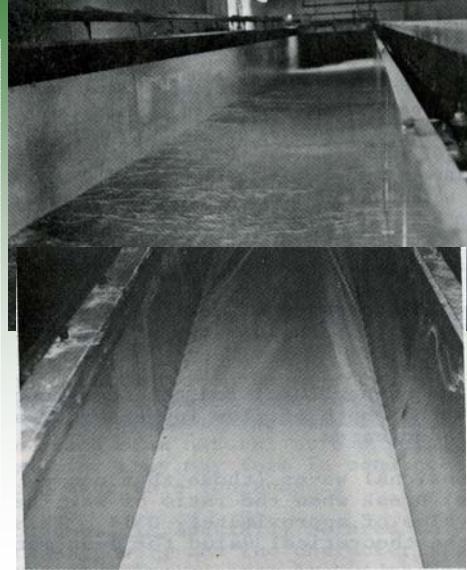
Transition - Washed Out Dunes

- Manning n
 - 0.014-0.025
- Concentration
 - 1,000 to 4,000 mg/L
- Water Surface Profile
 - Out of Phase
- Dominant Roughness
 - Form or Grain



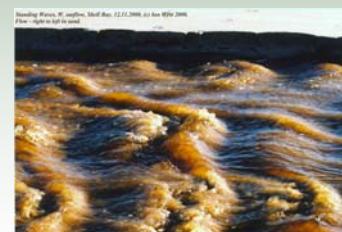
Upper Regime - Plane Bed

- Manning n
 - 0.010 to 0.013
- Concentration
 - 2,000 to 4,000 mg/L
- Water Surface Profile
 - Parallel
- Dominant Roughness
 - Grain



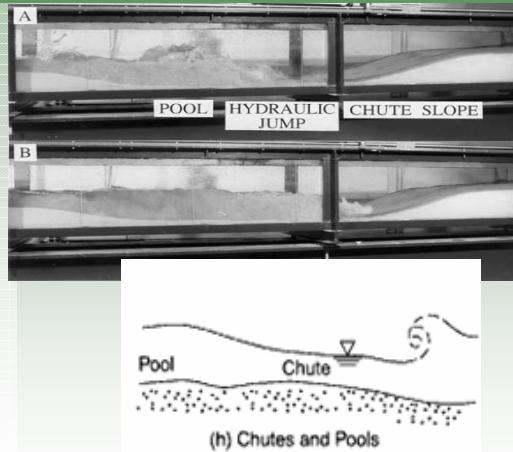
Upper Regime – Antidunes

- Manning n
 - 0.010 to 0.020
- Concentration
 - 2,000 to 5,000 mg/L
- Water Surface Profile
 - In Phase
- Dominant Roughness
 - Grain



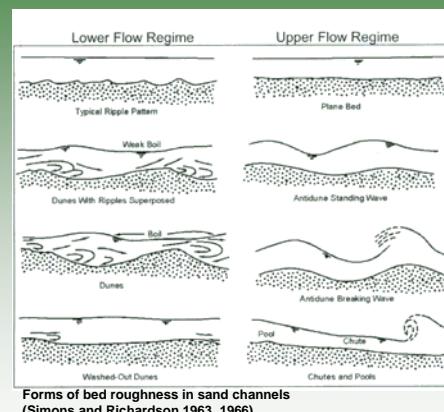
Upper Regime – Chutes and Pools

- Manning n
 - 0.018 to 0.035
- Concentration
 - 5,000 to 50,000 mg/L
- Water Surface Profile
 - In Phase
- Dominant Roughness
 - Variable

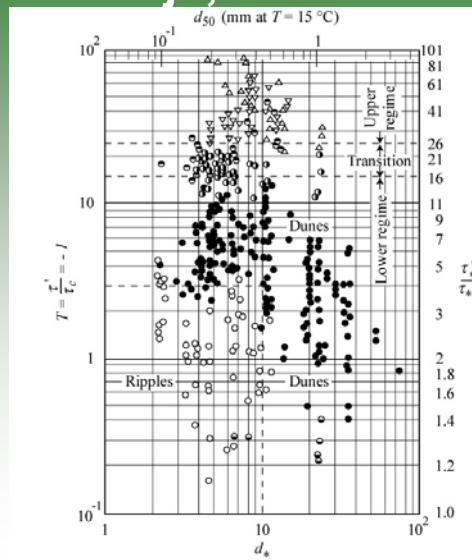


Bedform Classification

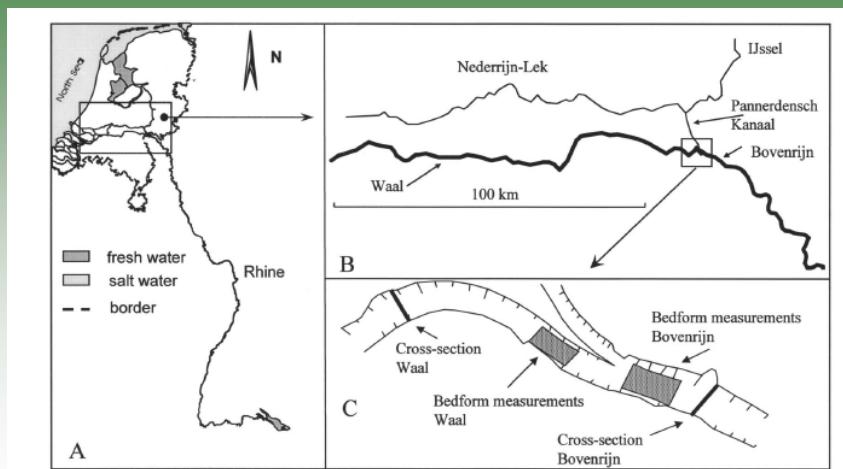
- Bedforms are classified based on:
 - Shape
 - Resistance to Flow (Energy Dissipation)
 - Sediment Transport
 - Relationship between the bed and water surface



Based on Transport-Stage Parameter van Rijn, 1984b



Study Area of the Rhine River



Field Surveys on the Rhine River



Bedform Profiles

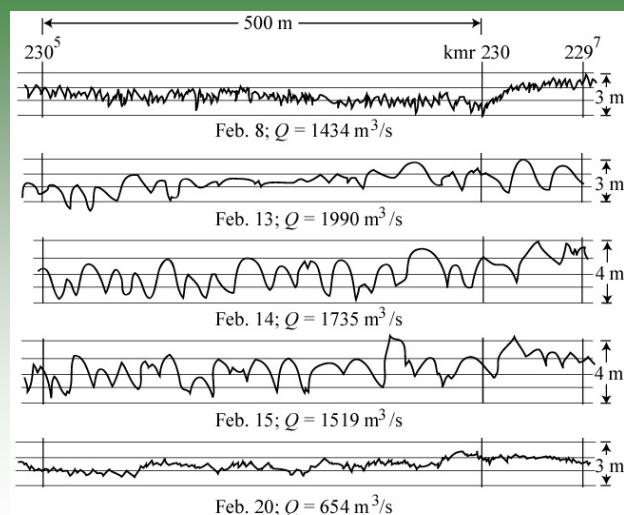


Figure 8.15. Dunes of the Bergsche Maas during the 1984 flood of the meuse River (kmr denotes river kilometer; after Adriaanse, 1986)

Dune Height during the Flood

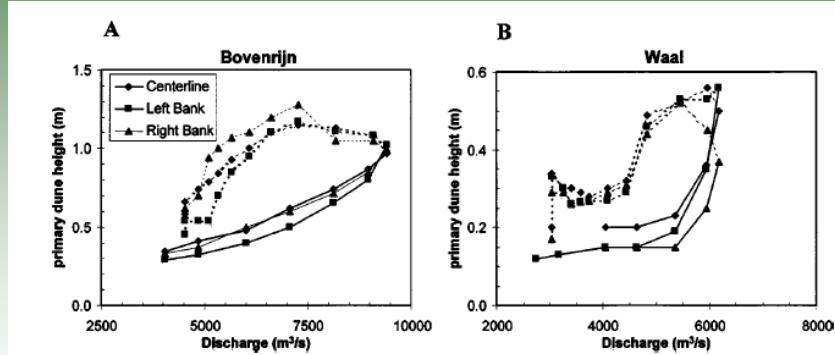


Fig. 3. Primary dune height versus discharge: (a) Bovenrijn and (b) Waal (dashed lines represent falling stage)

Manning n during the Flood

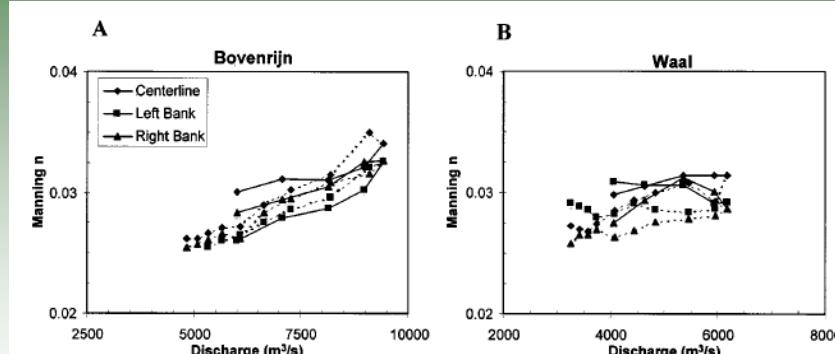
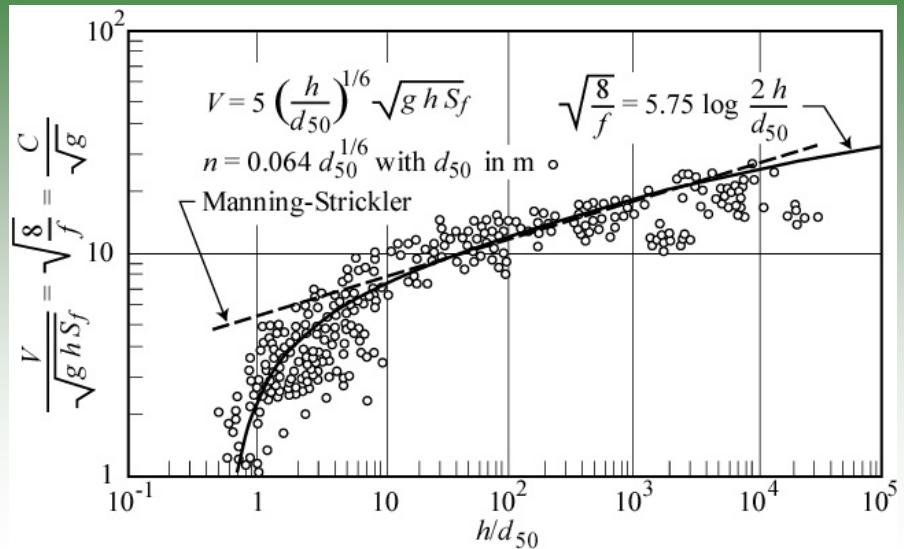
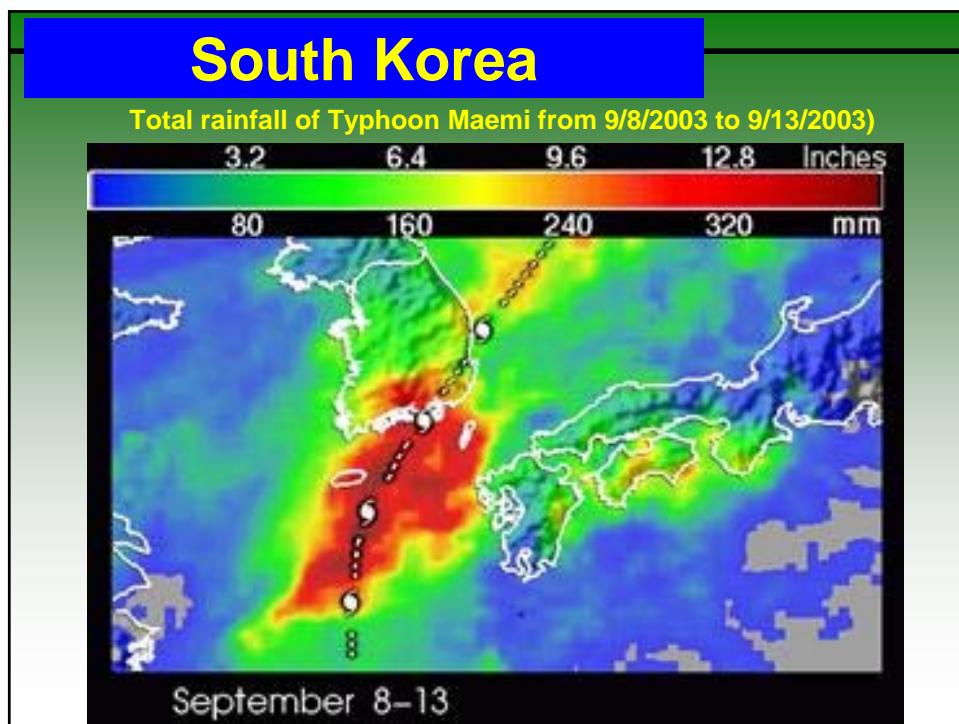


Fig. 6. Manning n versus discharge: (a) Bovenrijn and (b) Waal (dashed lines correspond to falling stage)

Resistance to Flow



Sedimentation Engineering

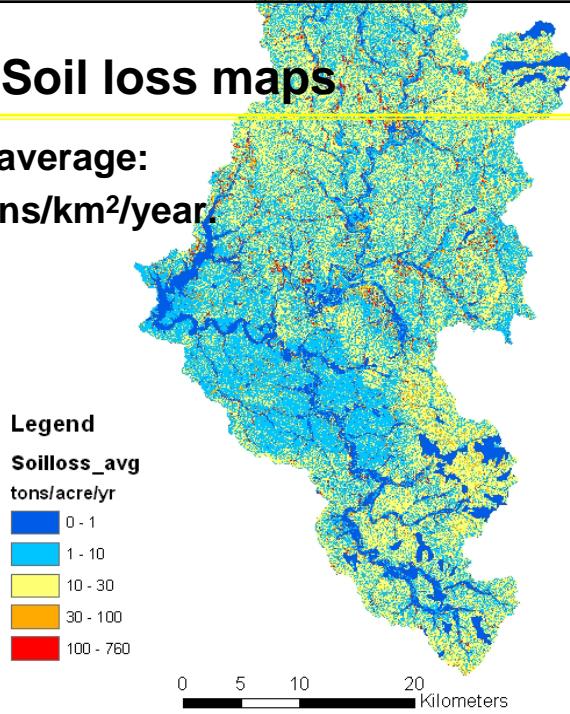


Imha Reservoir, South Korea

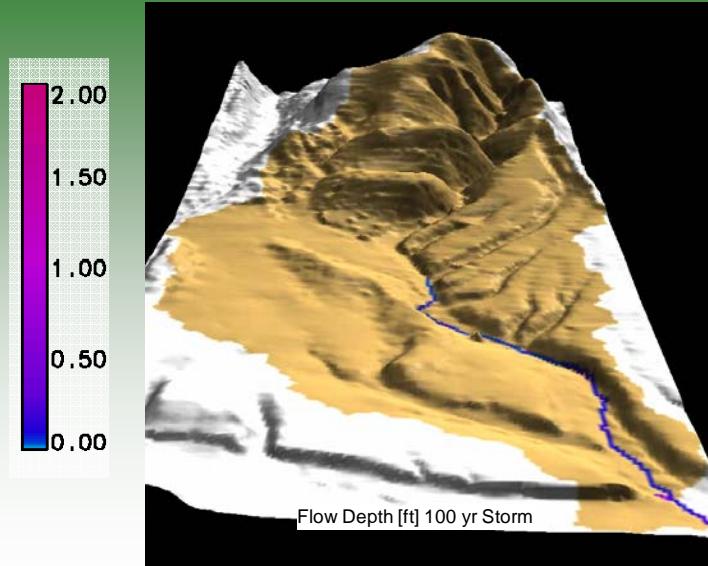


Soil loss maps

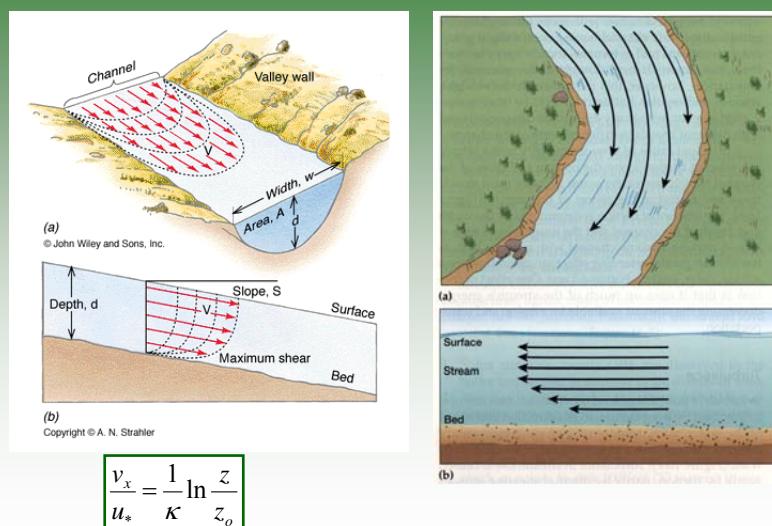
Annual average:
3,450 tons/km²/year.



CSU Watershed Model TREX

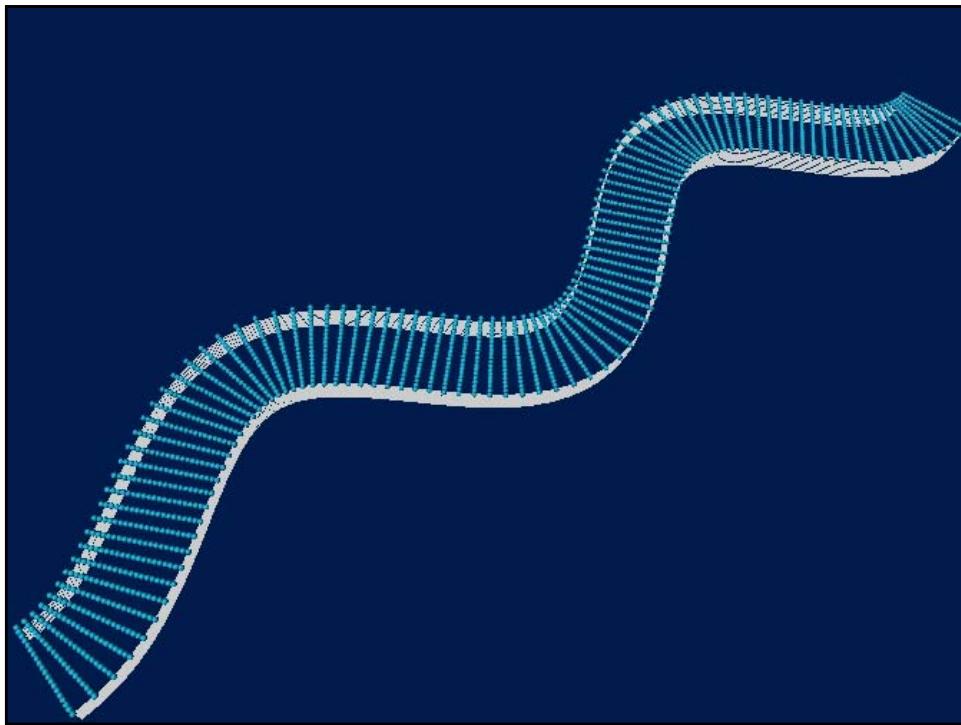
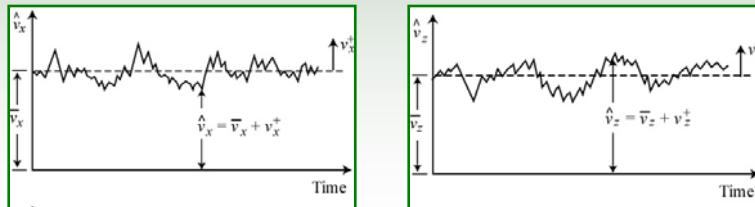


Logarithmic Velocity Profile



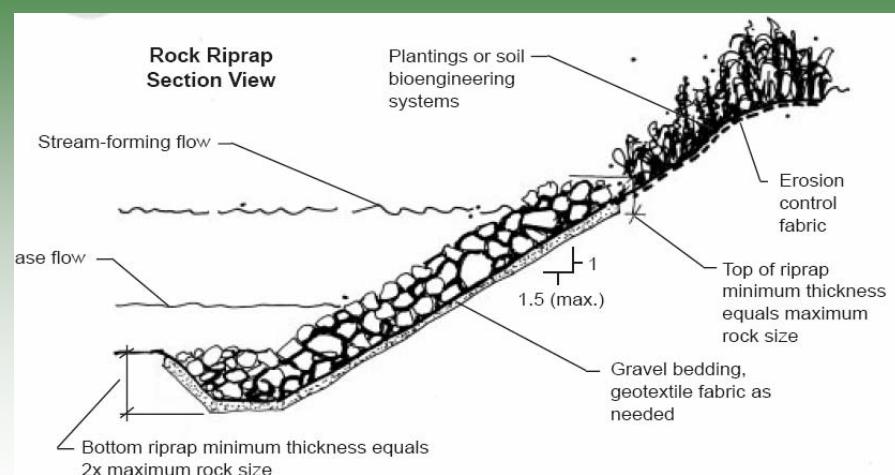
Turbulent Flow Equations

$$\begin{aligned}
 \frac{\partial v_x}{\partial t} + v_x \frac{\partial v_x}{\partial x} + v_y \frac{\partial v_x}{\partial y} + v_z \frac{\partial v_x}{\partial z} &= g_x - \frac{1}{\rho_m} \frac{\partial p}{\partial x} + \nu_m \nabla^2 v_x - \left[\frac{\partial v_x^+ v_x^+}{\partial x} + \frac{\partial v_y^+ v_x^+}{\partial y} + \frac{\partial v_z^+ v_x^+}{\partial z} \right] \\
 \frac{\partial v_y}{\partial t} + v_x \frac{\partial v_y}{\partial x} + v_y \frac{\partial v_y}{\partial y} + v_z \frac{\partial v_y}{\partial z} &= g_y - \frac{1}{\rho_m} \frac{\partial p}{\partial y} + \nu_m \nabla^2 v_y - \left[\frac{\partial v_x^+ v_y^+}{\partial x} + \frac{\partial v_y^+ v_y^+}{\partial y} + \frac{\partial v_z^+ v_y^+}{\partial z} \right] \\
 \underbrace{\frac{\partial v_z}{\partial t} + v_x \frac{\partial v_z}{\partial x} + v_y \frac{\partial v_z}{\partial y} + v_z \frac{\partial v_z}{\partial z}}_{local} &= \underbrace{g_z}_{gravitational} - \underbrace{\frac{1}{\rho_m} \frac{\partial p}{\partial z}}_{pressure gradient} + \underbrace{\nu_m \nabla^2 v_z}_{viscous} - \underbrace{\left[\frac{\partial v_x^+ v_z^+}{\partial x} + \frac{\partial v_y^+ v_z^+}{\partial y} + \frac{\partial v_z^+ v_z^+}{\partial z} \right]}_{turbulent fluctuation}
 \end{aligned}$$

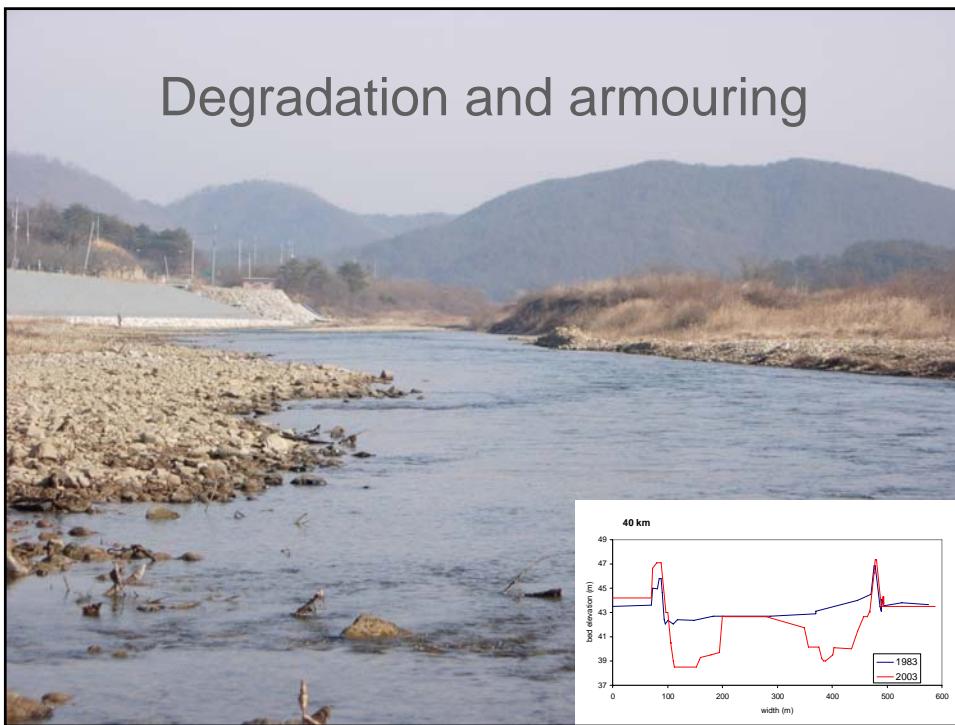
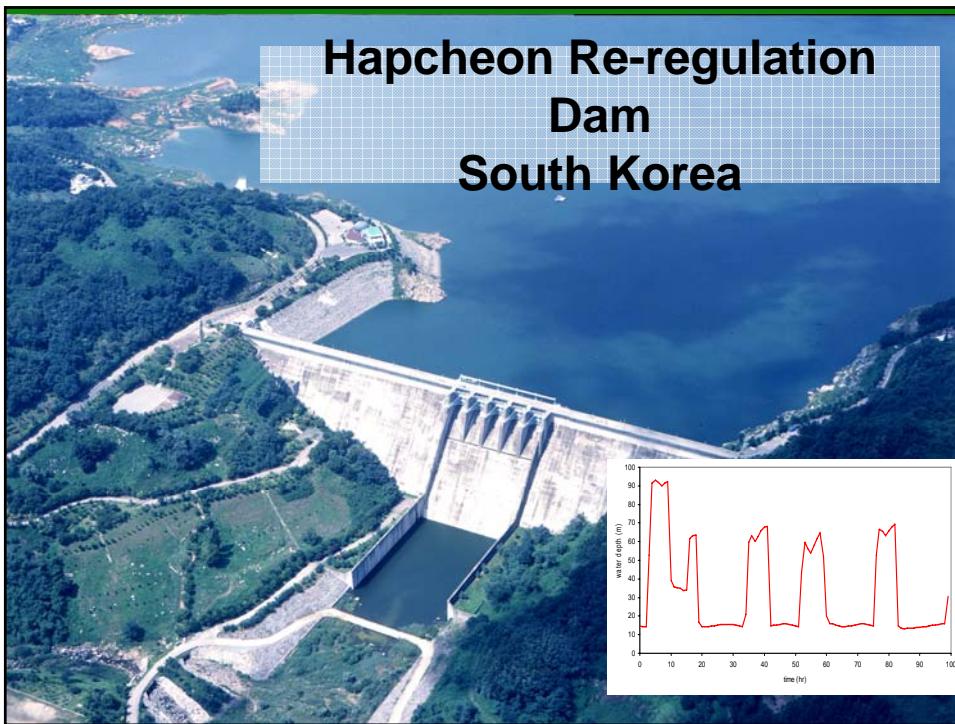




Riprap Design



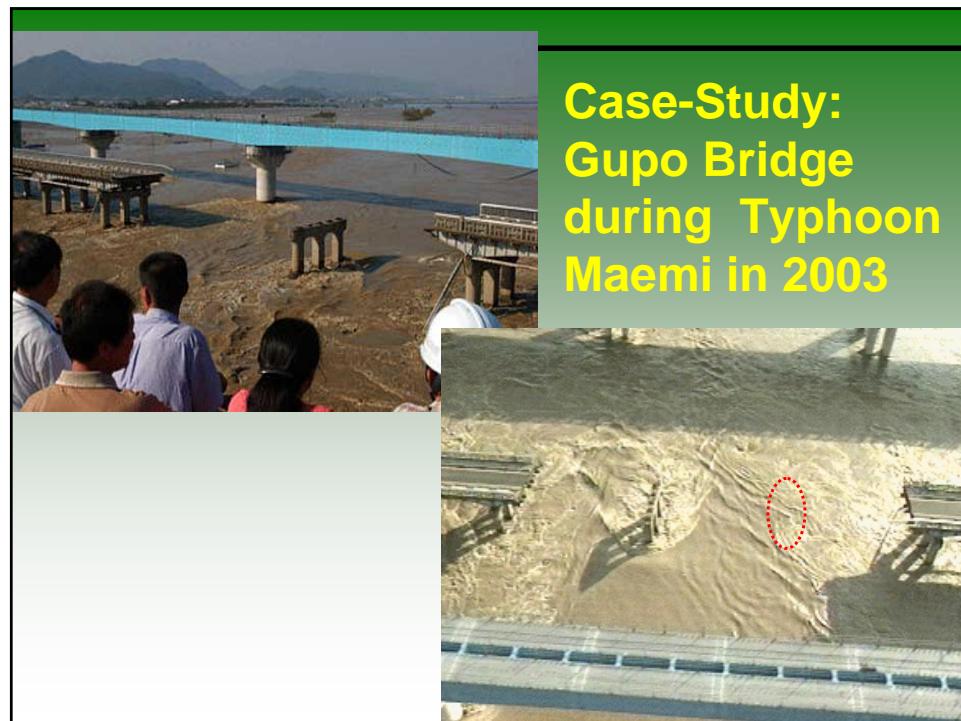


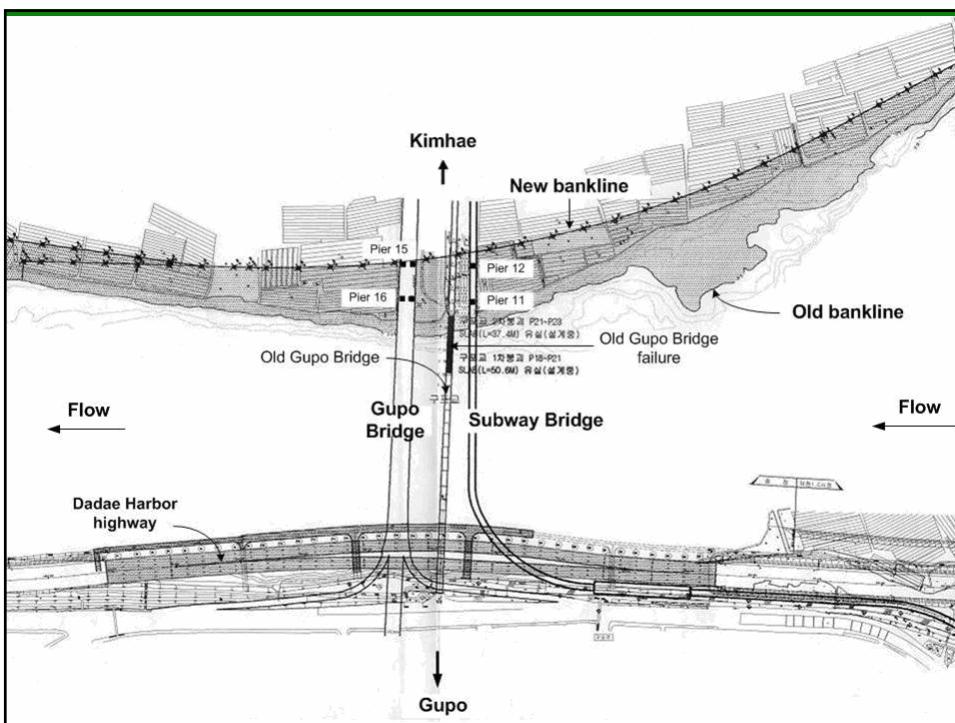


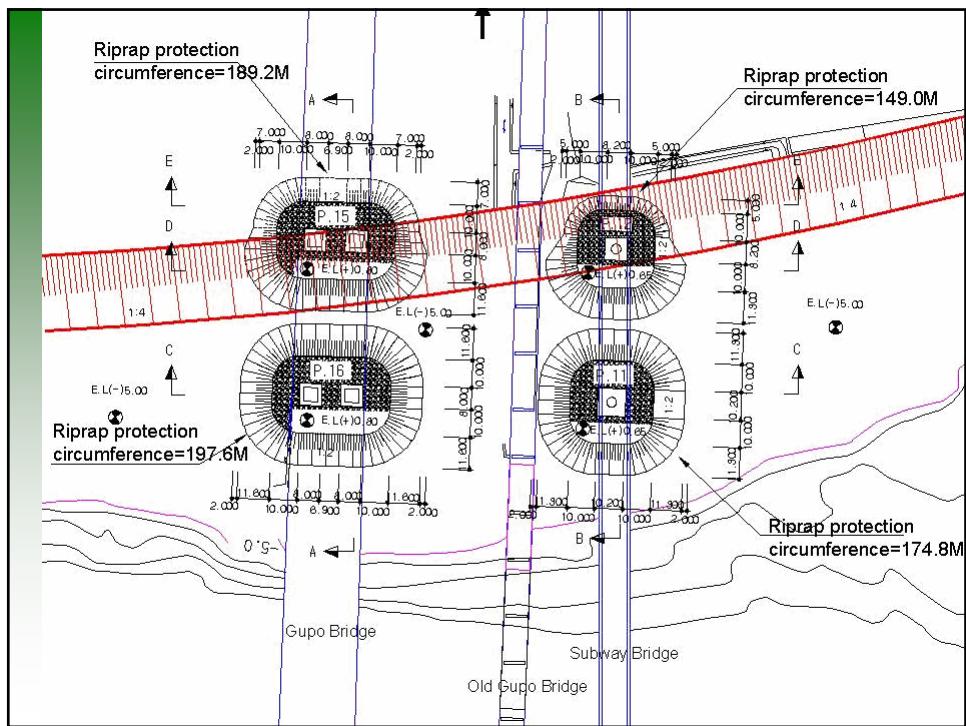
River changes below Hapcheon dam



Nakdong River Estuary Barrage







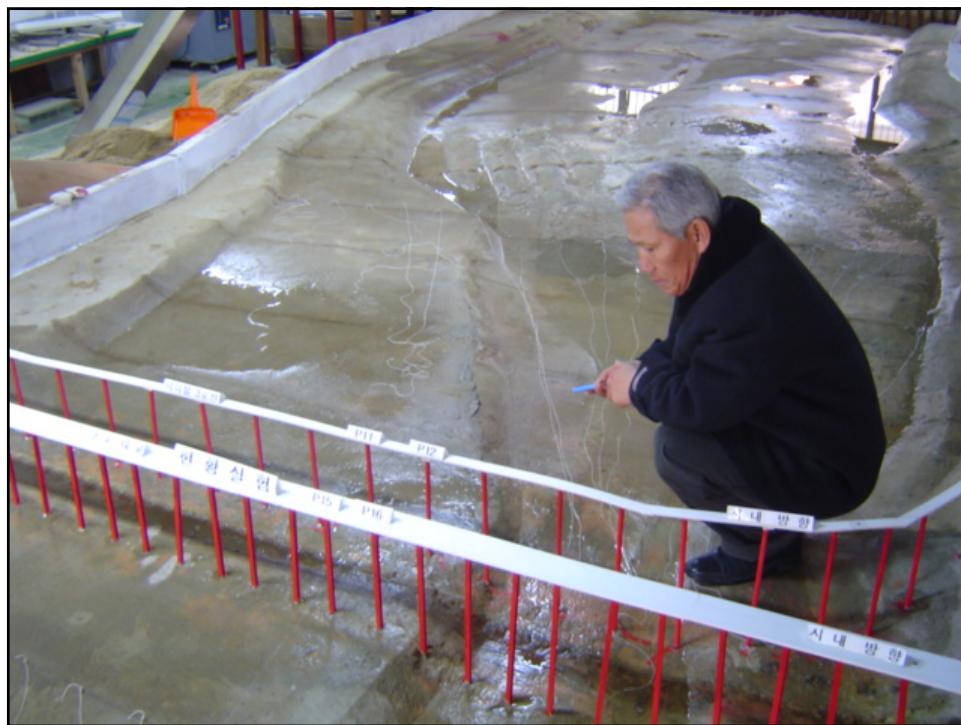
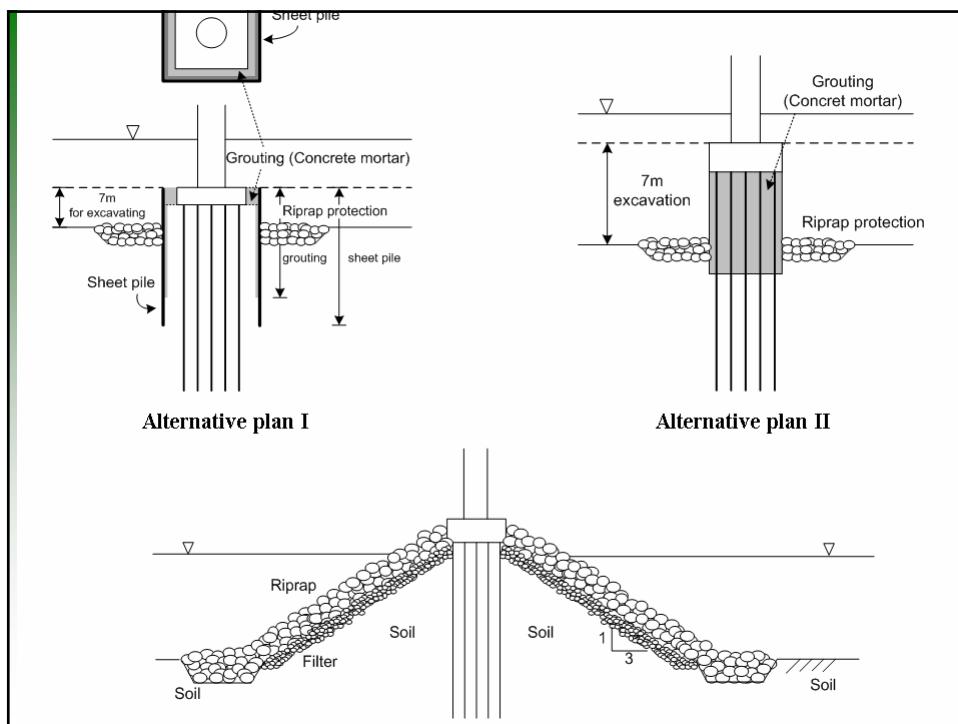


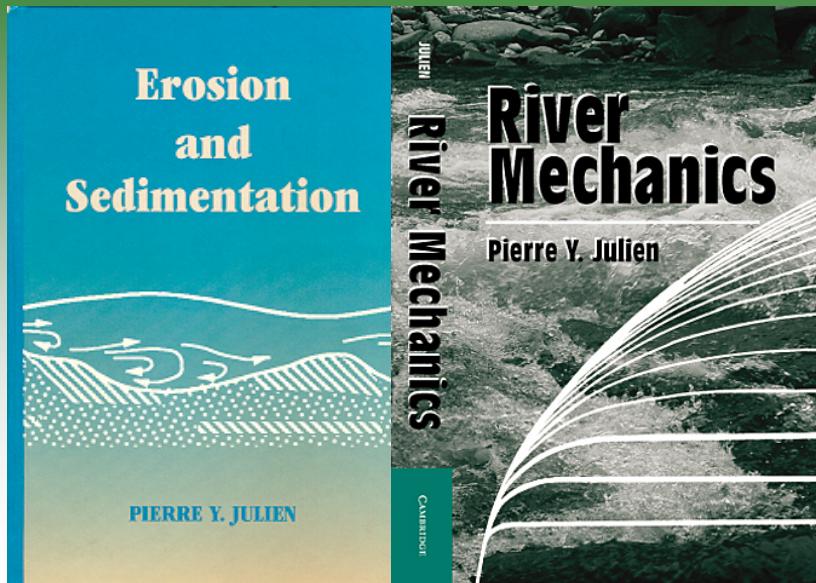


Figure 12. Experiment results with synthetic filters



Figure 14. Gupo and Subway Bridge Piers before and after retrofitting construction

Erosion and River Mechanics Textbooks



Acknowledgments

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Terima Kasih!

pierre@engr.colostate.edu