ASSESSING THE POTENTIAL FOR SEEPAGE BARRIER DEFECTS TO PROPAGATE INTO SEEPAGE EROSION MECHANISMS

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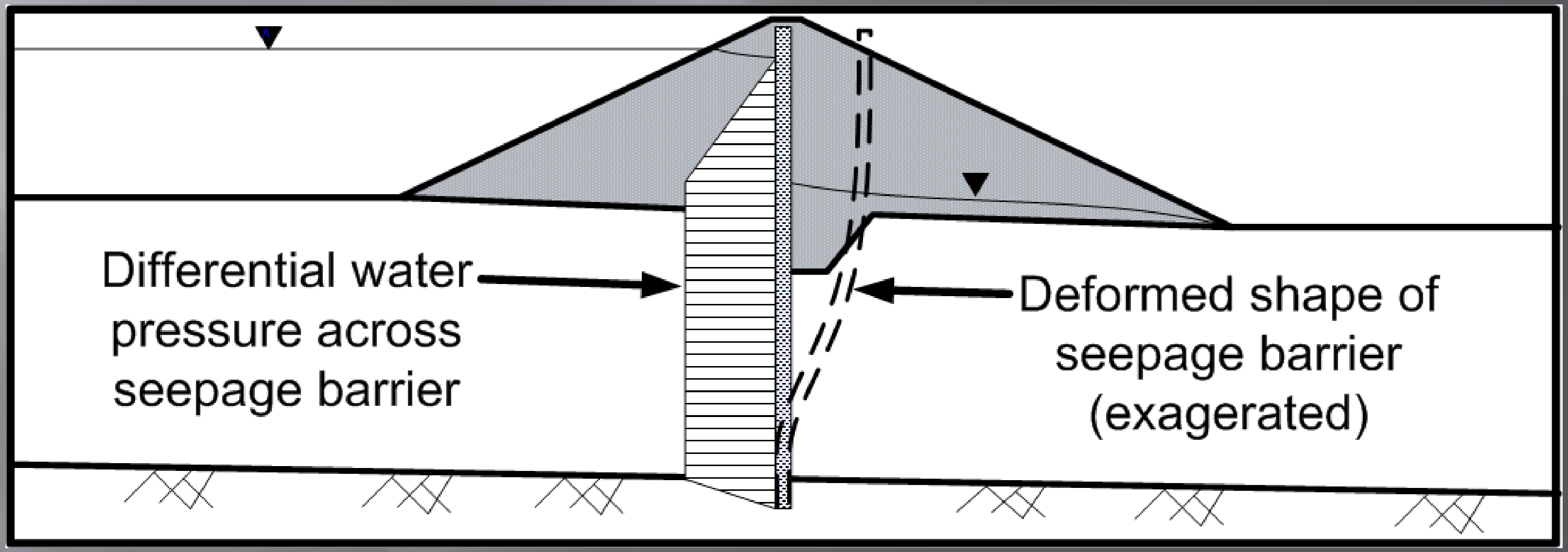
Background – Seepage Barrier Cracking

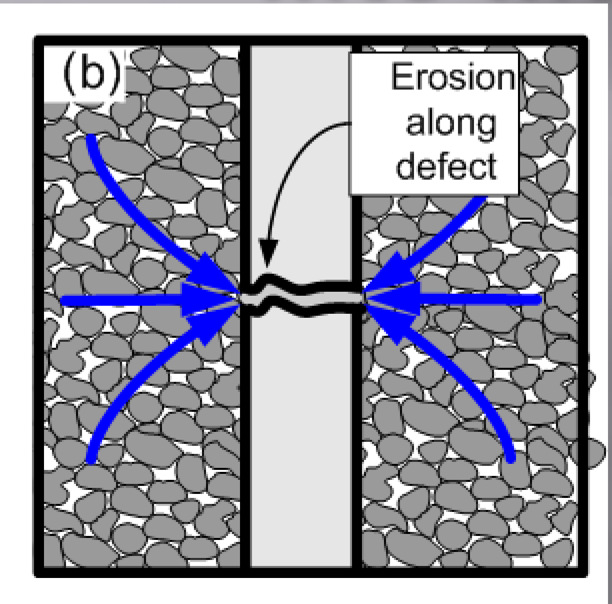
- Cracking in Seepage Barriers due to deformation (Rice and Duncan 2010)

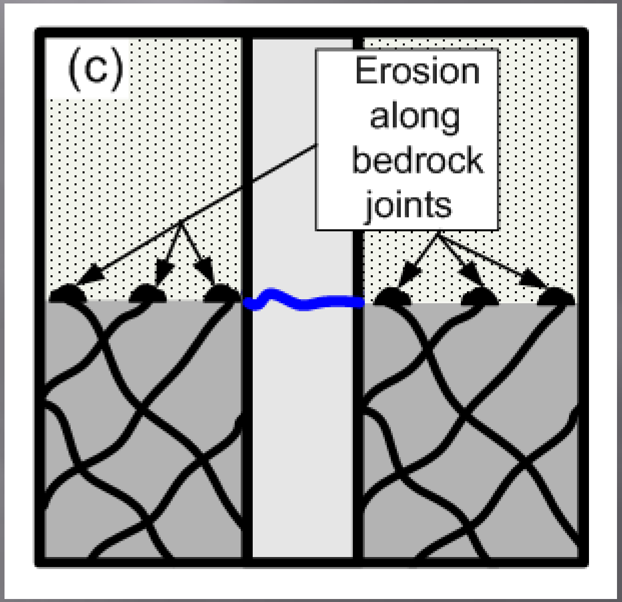


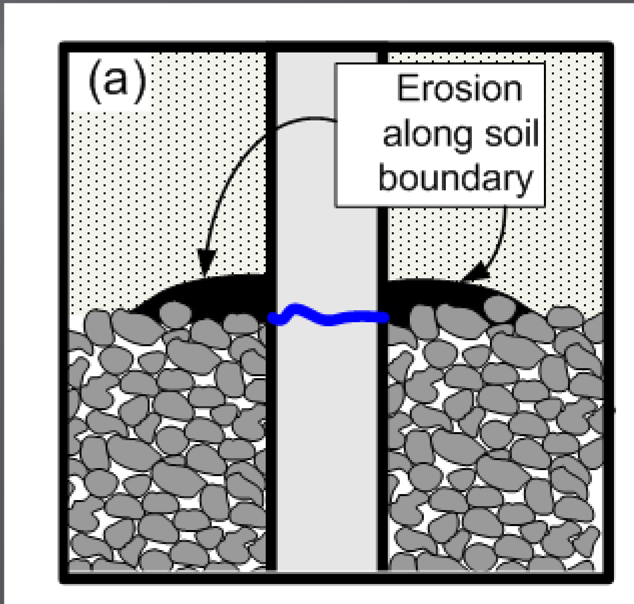
Seepage Barrier Cracking – SCB Walls

Photos from George Sills 2010

Background – Can SB Cracks Develop into Internal Erosion/Piping?



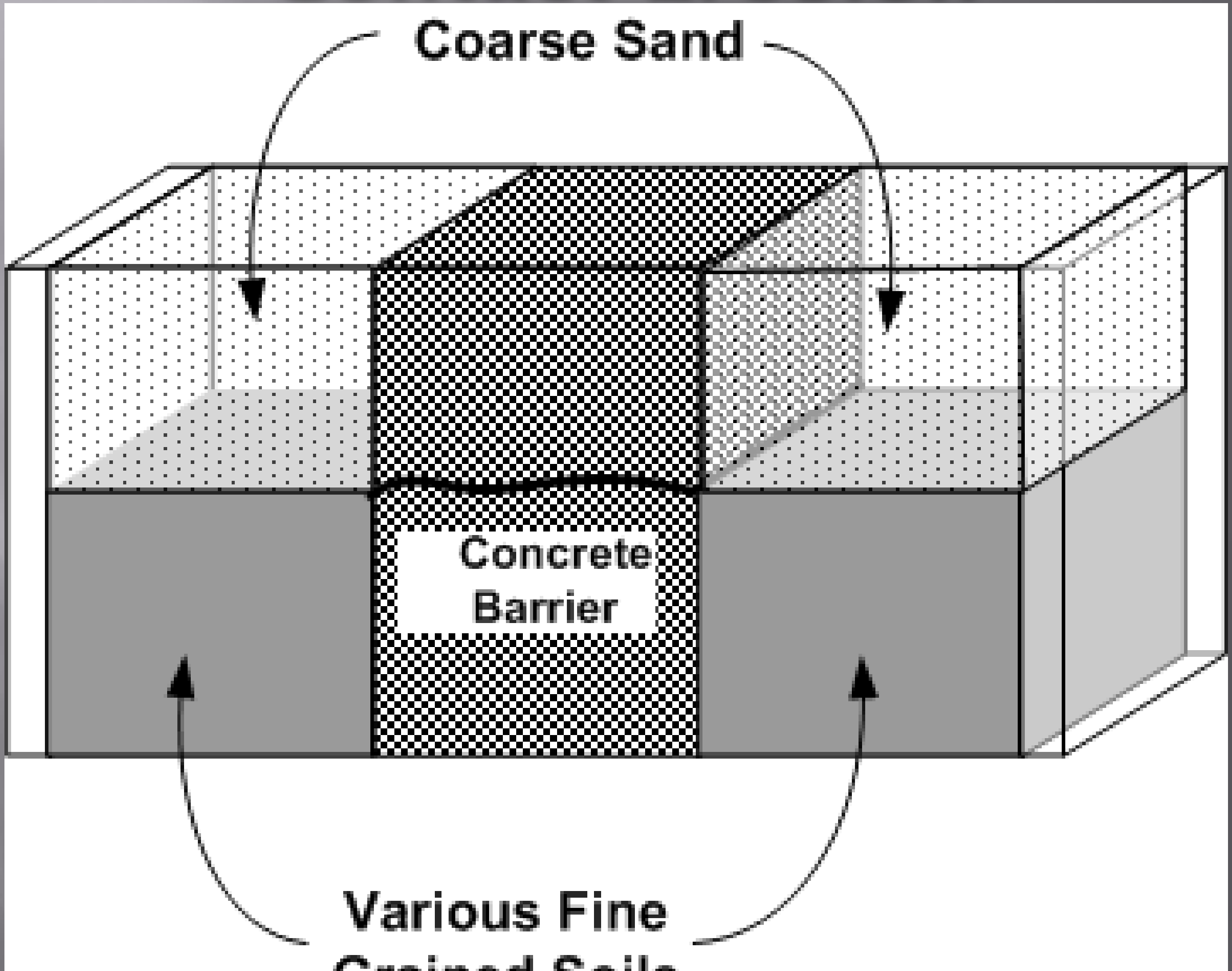




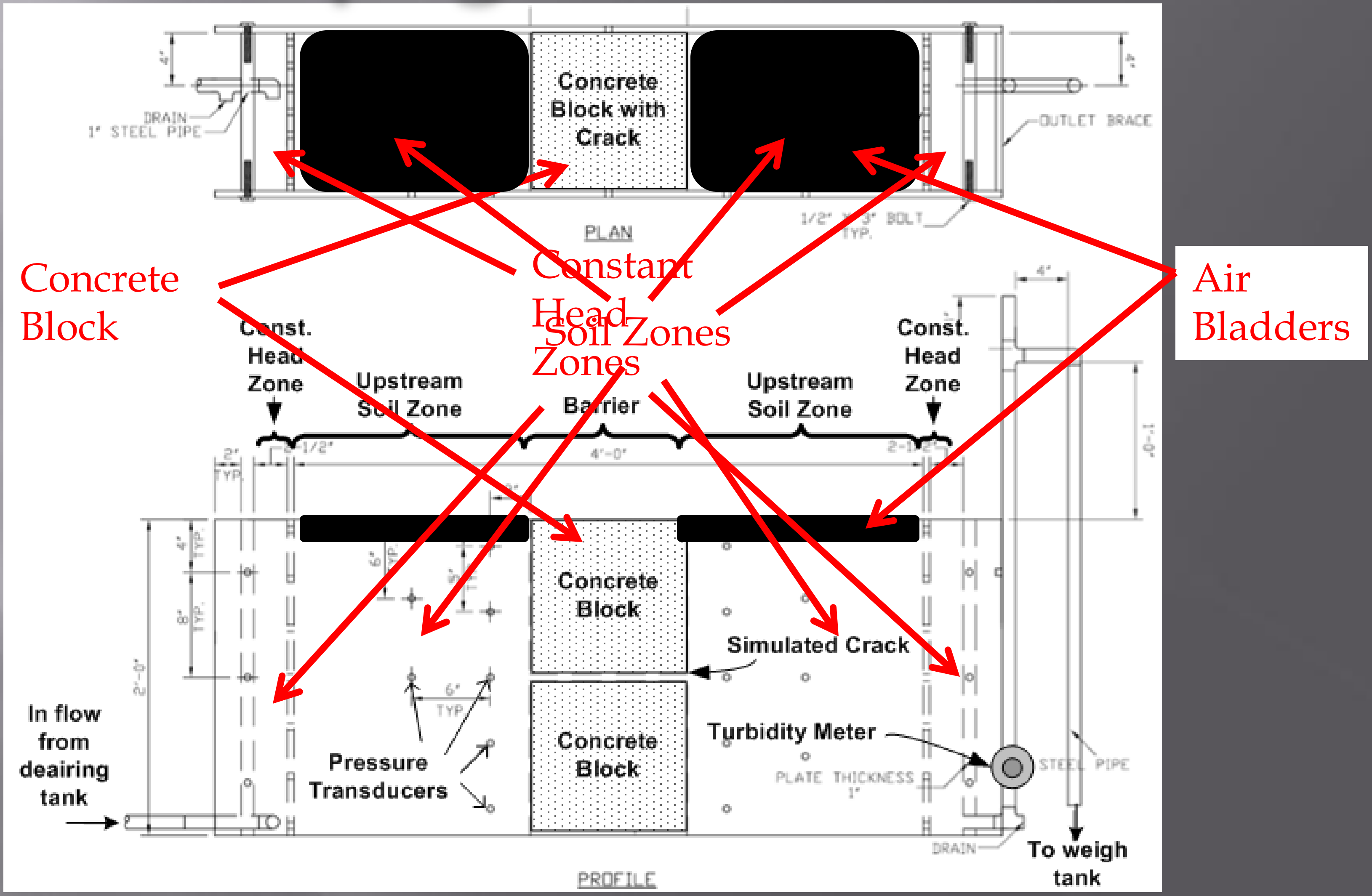
Study Methods

- Conduct laboratory experiments to model erosion behavior at a soil interface near a seepage barrier crack.
- Perform finite-element seepage analyses to model laboratory experiments.
- Compare results from experiments and finite-element analysis.

Test Program – Concentrated Contact Erosion

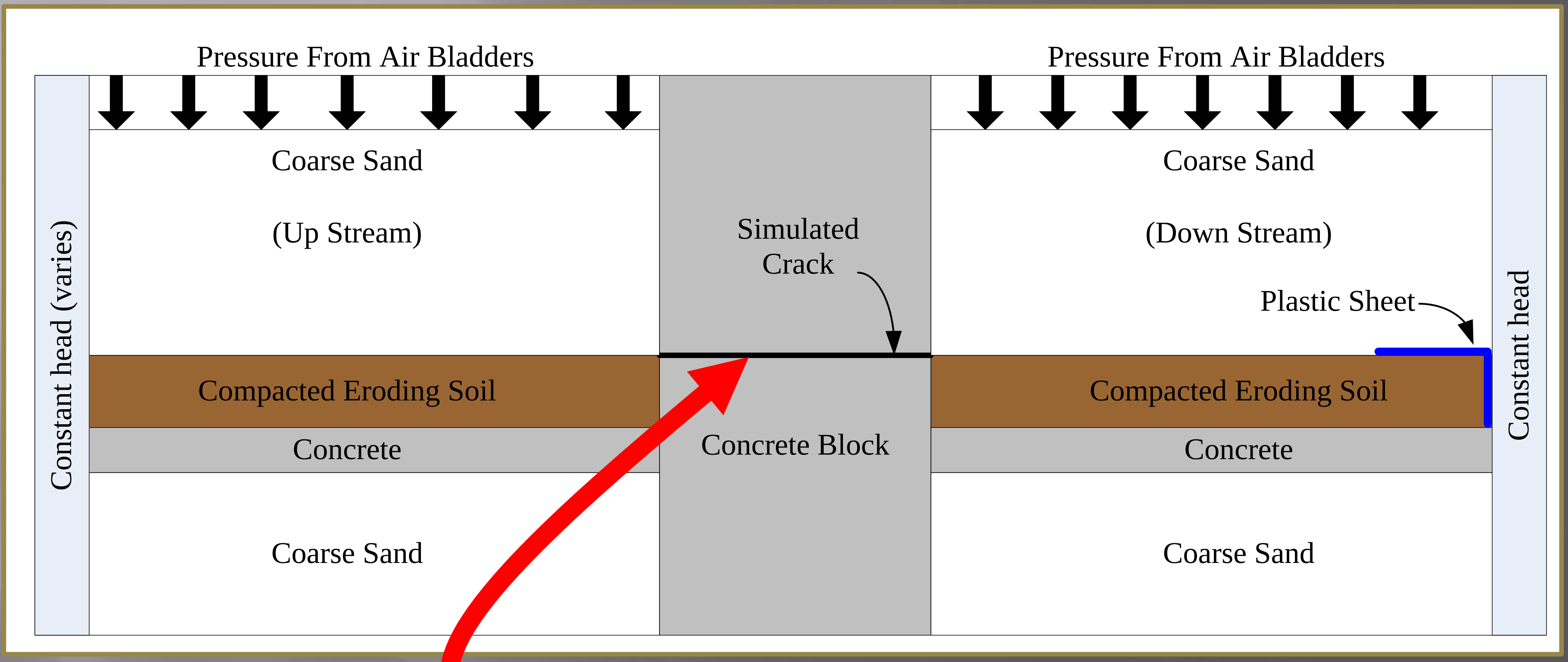


Seepage Test Cell



Seepage Test Cell

Initial Test Program

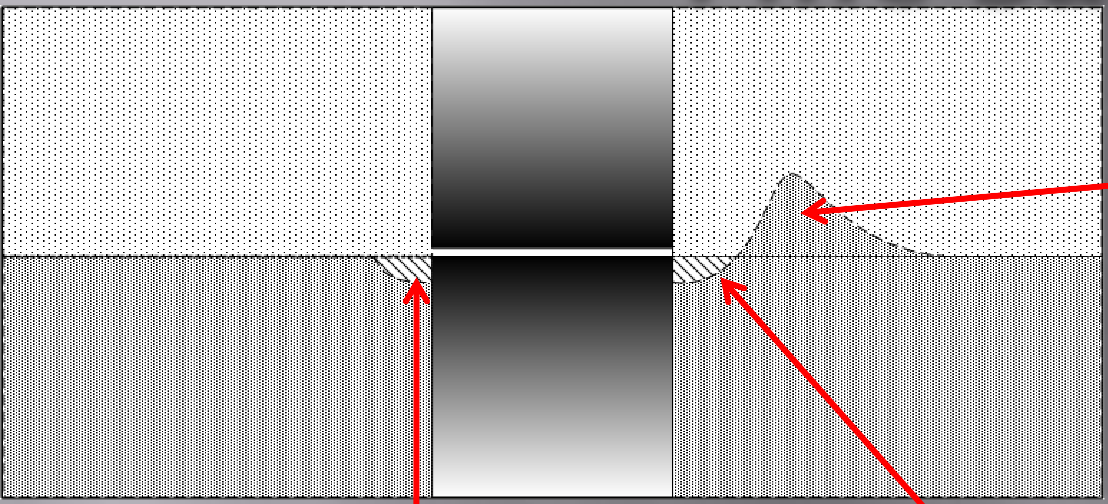


Tests performed for each eroding soil at crack apertures of 0.5 and 1.0mm

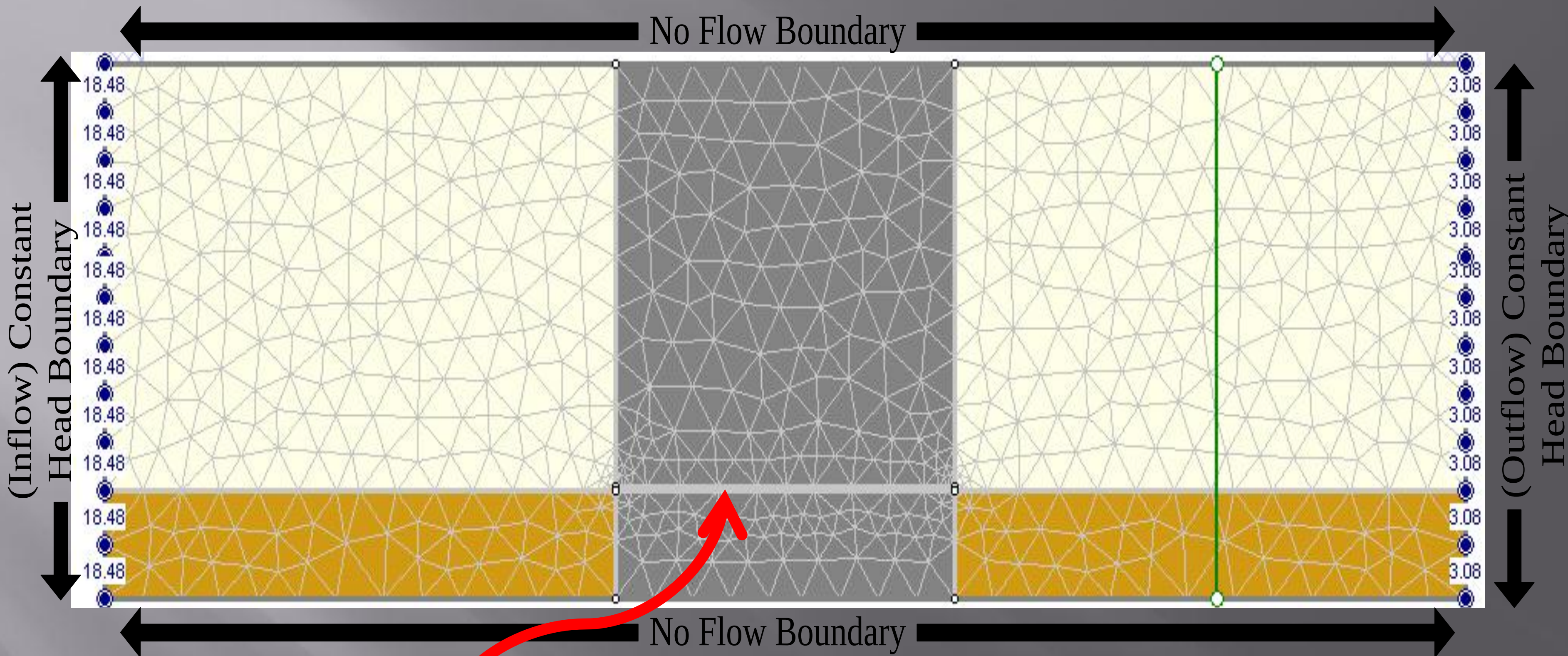
Initial Test Program

Soil	Optimum Water Content (%)	Unit Weight (pcf)	Permiability (cm/s)	PL	LL	PI
Coarse Sand	NA	90	8.00E-02	NA	NA	NA
Fine Sand	NA	109	3.00E-03	NA	NA	NA
Silt	14.5	117	1.50E-05	16	19	3
Clay	28.5	116	3.00E-08	33	49	16

Erosion/Deposition Patterns Fine Sand

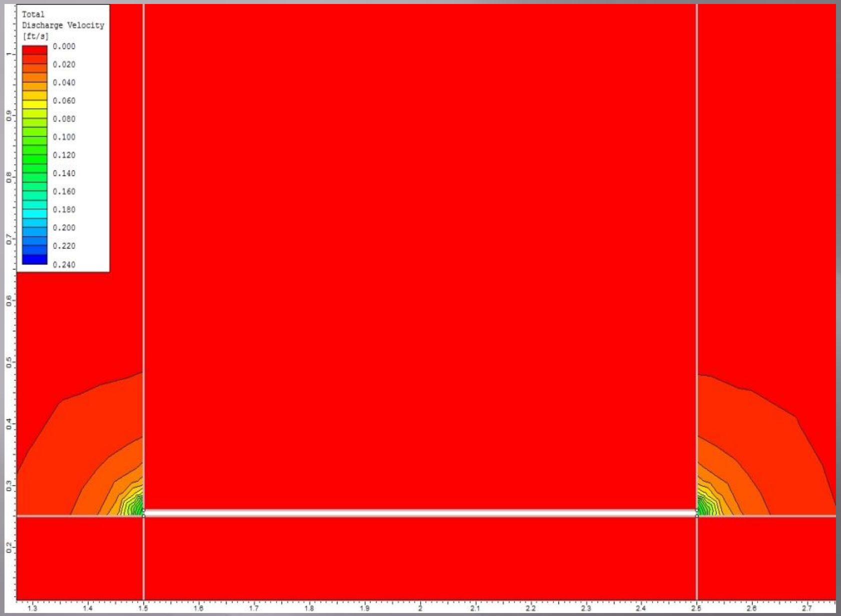


FEM Modeling

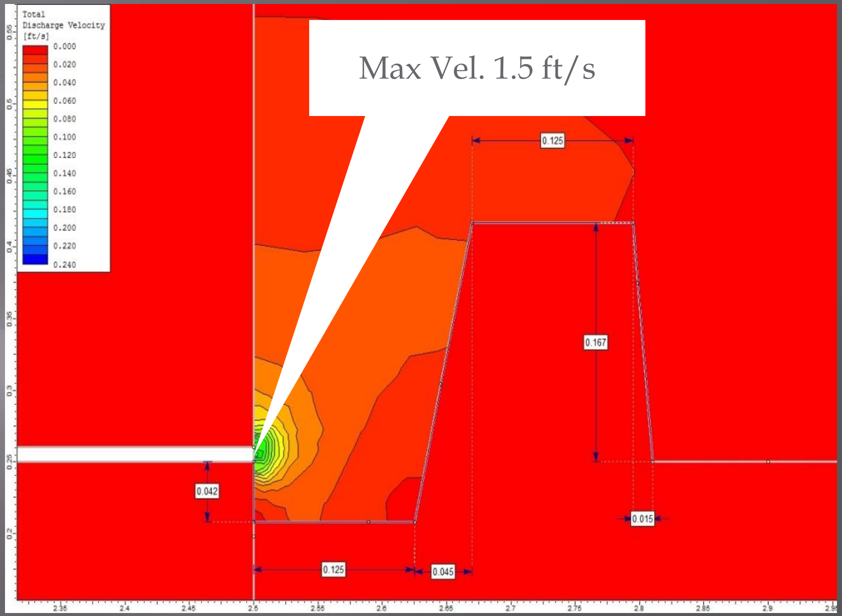


Crack modeled as ¼-inch high zone with hydraulic conductivity set to give equivalent transmissivity as the actual crack (laboratory measured)

Sand FEM Results



Test S1 Slide results
(pre erosion)



Test S1 Slide results
(post erosion –down stream)

Estimated Erosive Velocity = 0.66 to 0.98 ft/s

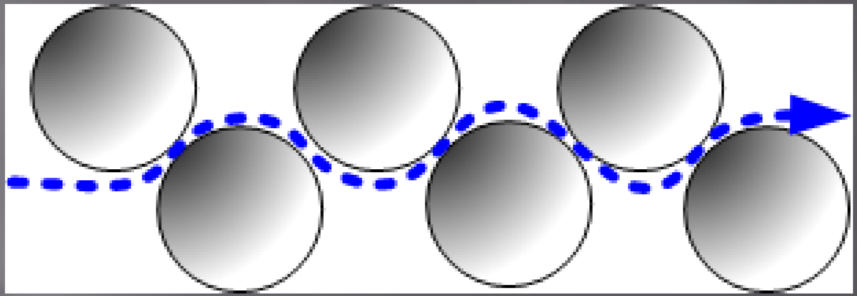
Adjusting FEM Calculated Velocities

FEM-calculated velocity in the course sand is a "discharge" or "Darcy" velocity that must be adjusted for:

- Porosity

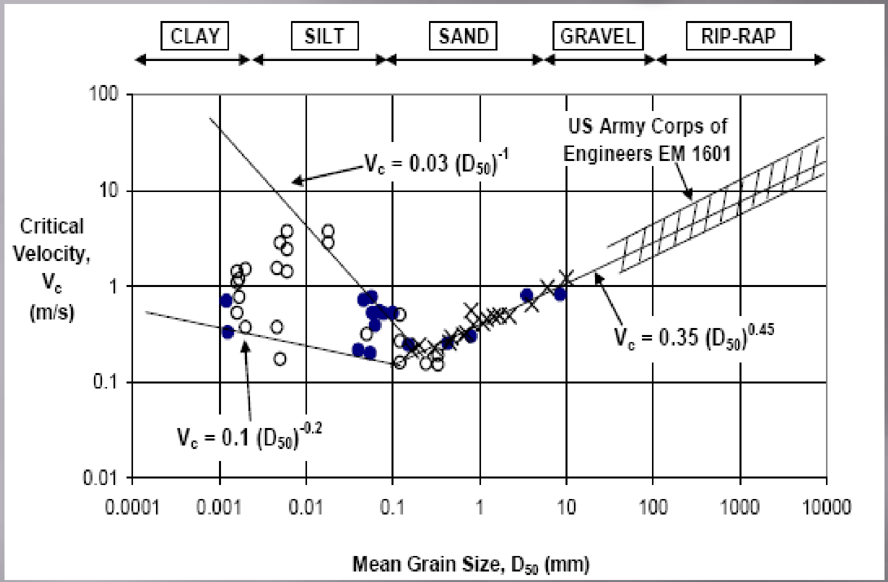
$$Flow\ Velocity = \frac{Dischage\ Velocity}{Porosity}$$

- Tortuosity

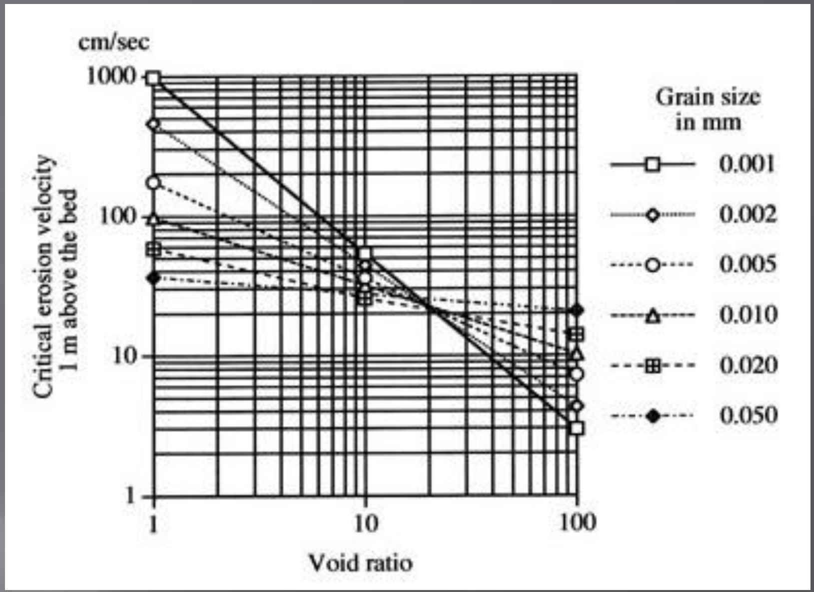


$$Particle\ Velocity = Flow\ Velocity \times 2$$

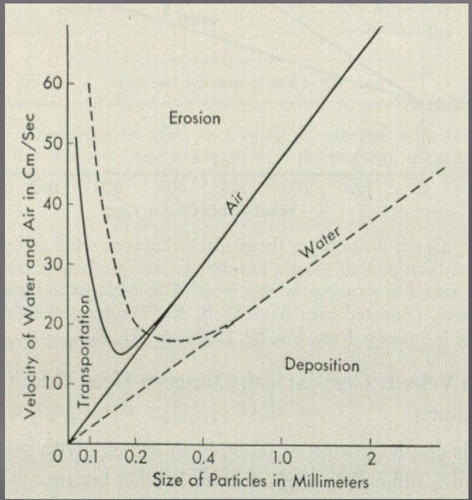
Estimating Erosive Velocities



(Briaud, 2010)

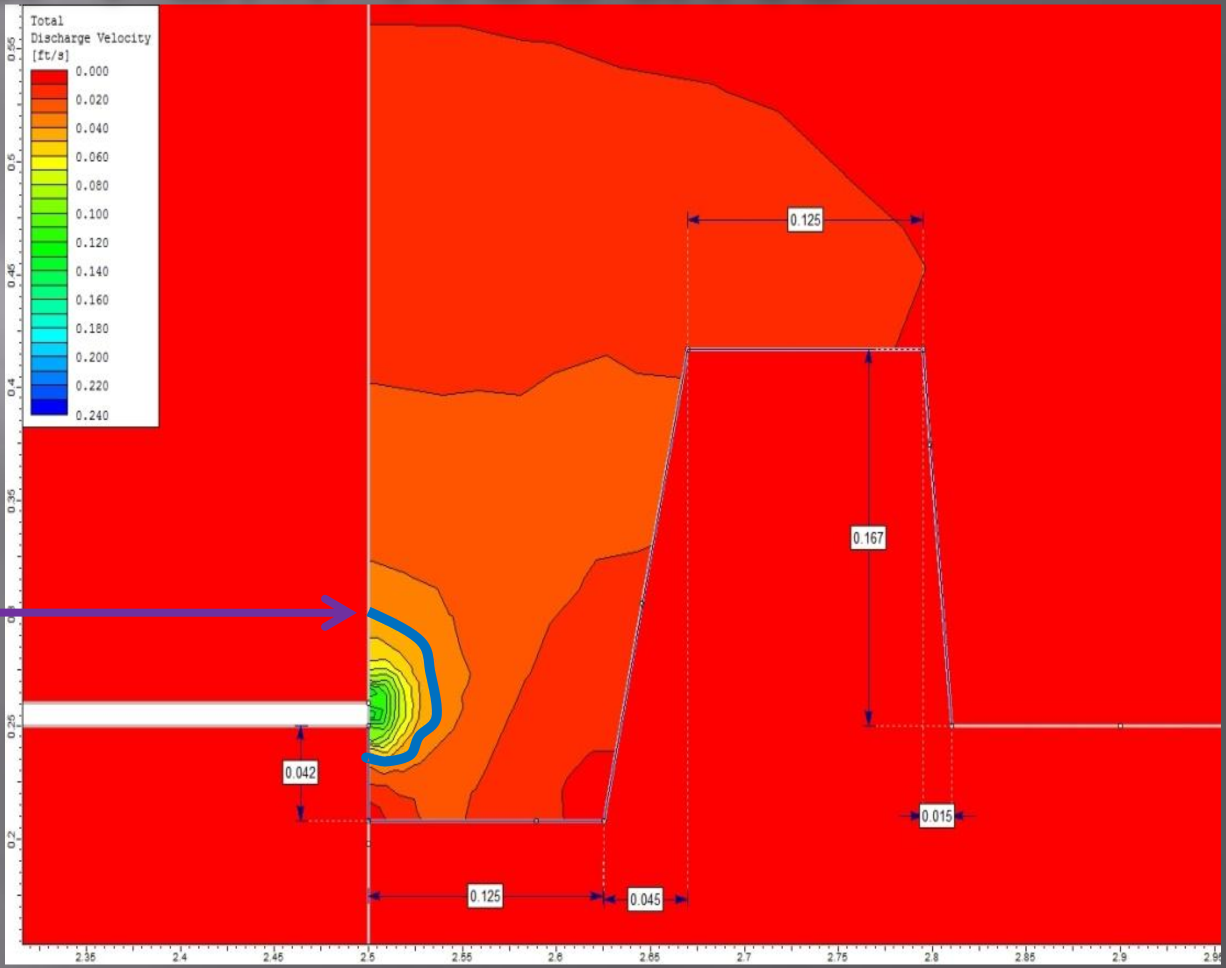


(Axelsson, 2002)



(Garrels, 1951)

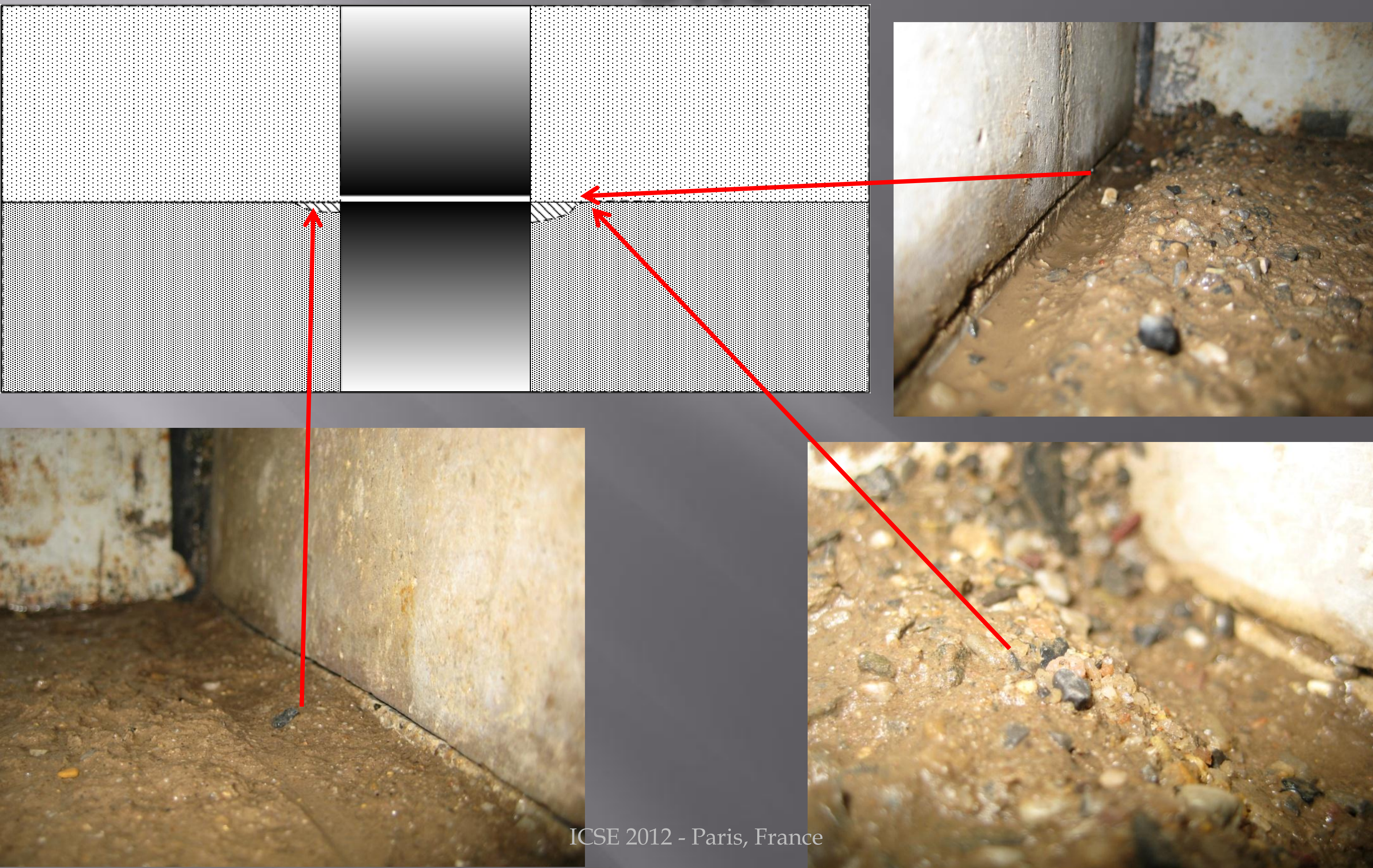
Sand FEM Results



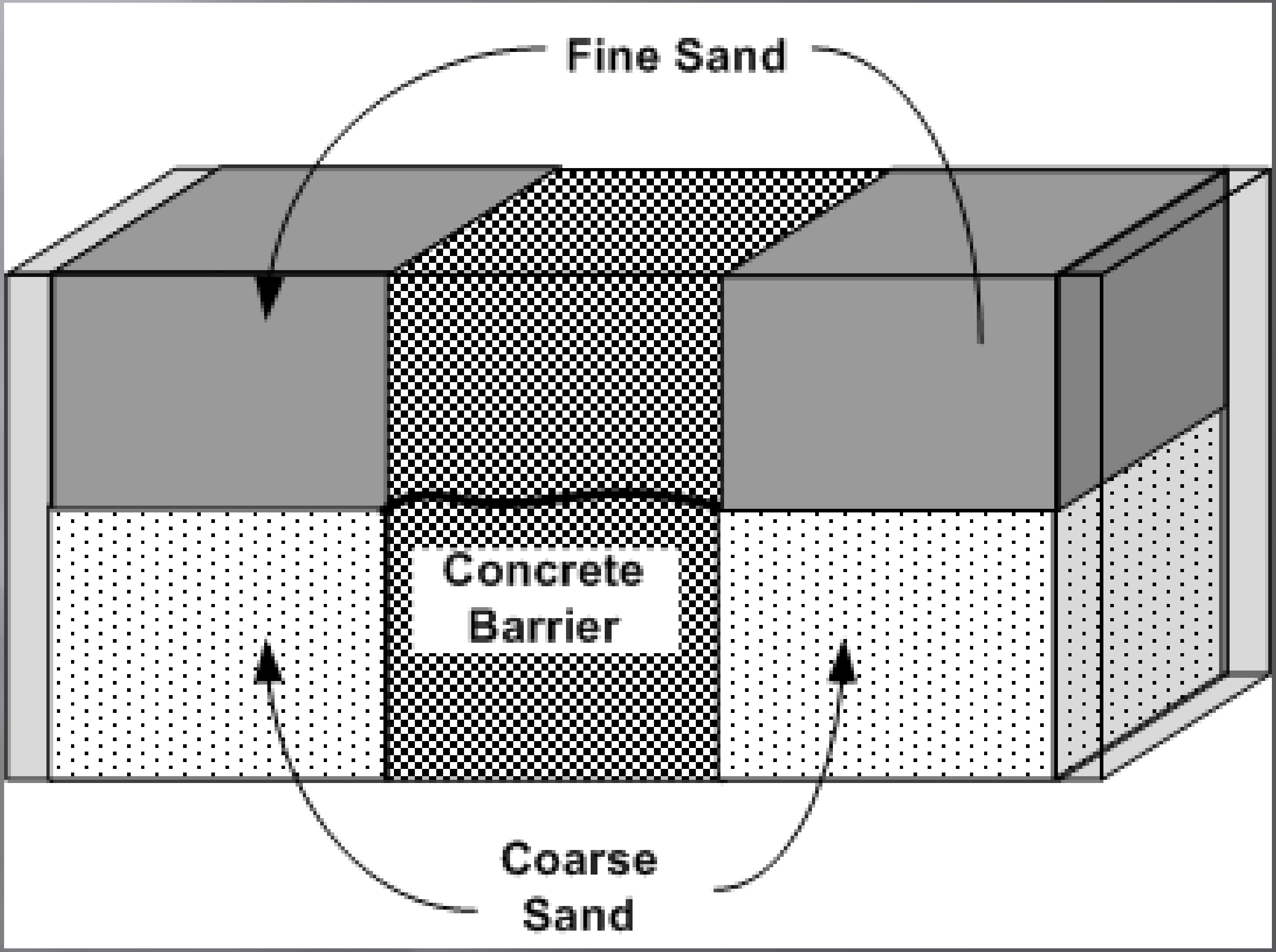
Approx. extent of Adjusted erosive velocity

Estimated Erosive Velocity = 0.66 to 0.98 ft/s

Erosion/Deposition Patterns Silt



Coarse Sand on Bottom



Coarse Sand on Bottom

Conclusions – FEM Correlation

- FEM results correlated fairly well with observed upstream erosion.

- Less correlation with observed downstream erosion.

- Downstream erosion appears to be controlled by non-Darcian (jetting) crack flows.

Conclusions – Soil Behavior

Varied erosion/transport/deposition processes observed in various soils

- Sand:
  - Particle erosion
  - Bedload transport – rapid deposition.
- Silt:
  - Particle erosion?
  - Suspension transport – further transport
- Clay:
  - Clump erosion
  - Bedload transport – rapid deposition

Conclusions – Soil Behavior

When soils are easily transported (inverted models):

- soils with collapsible roof showed sink hole development

Questions?