Hurricane Damage on Flood Protection System and Multidisciplinary Countermeasure

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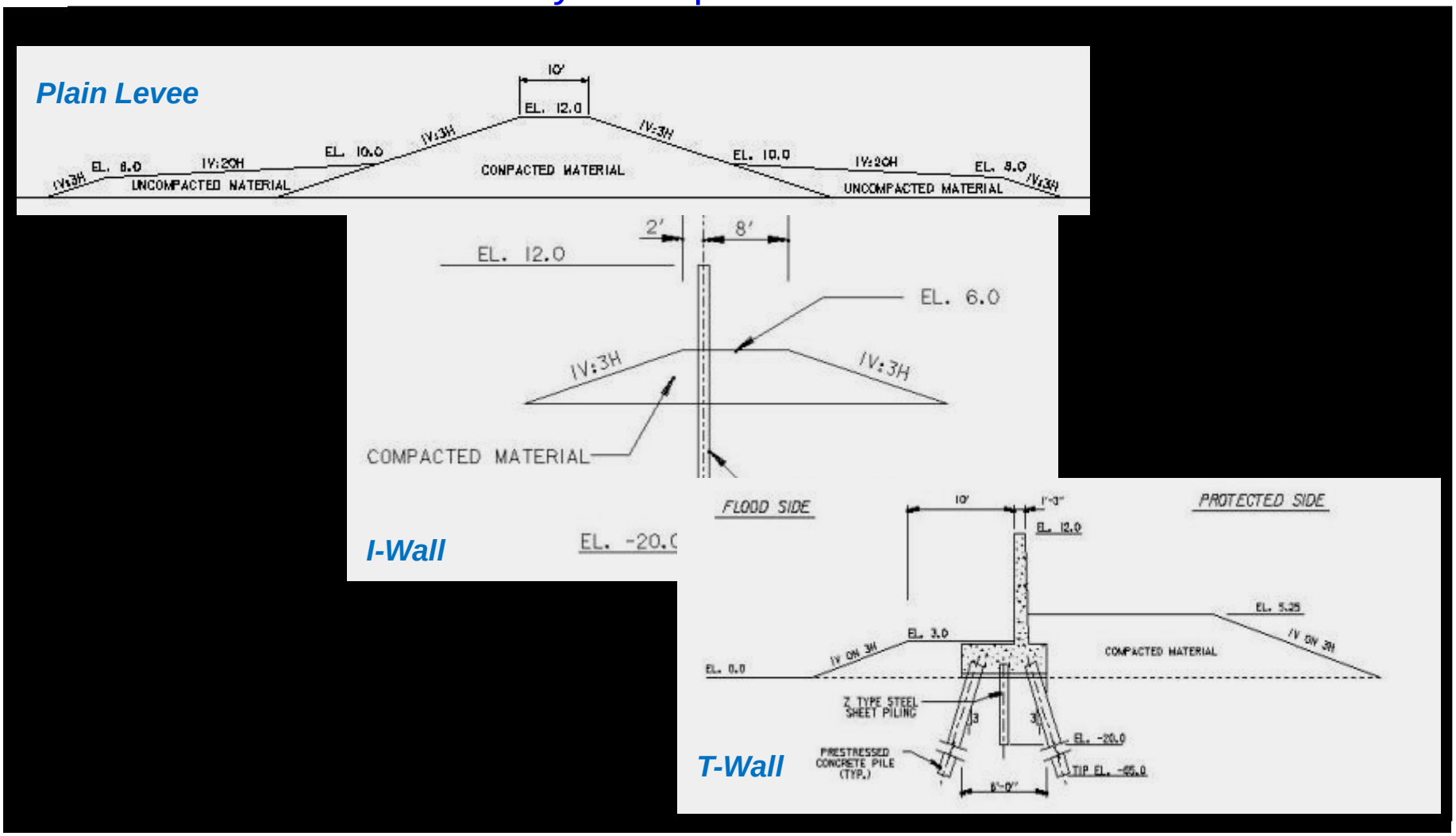
Motivation

- Current practices of levee design, construction, and maintenance did not provide adequate protection as shown during Hurricane Katrina, 2005 and several other severe weather conditions.
- Unprecedented severe weather condition might be due to global warming, but we should prepare for worse conditions.
- Building even more massive flood protection systems will require substantial monetary burdens.
- This study develops a technique that is economic but provide multiple layers of protection to existing and new flood protection system through multidisciplinary research.

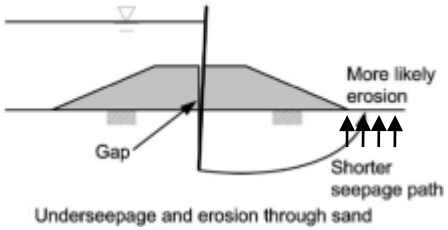
Overview

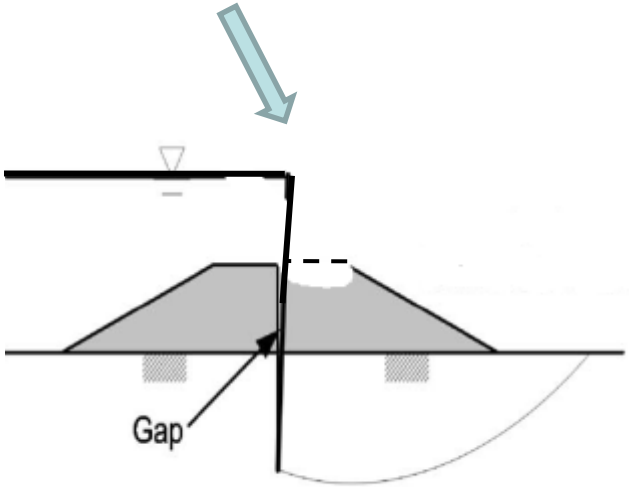
General schematics of major hurricane protection structures in New Orleans and many other places.

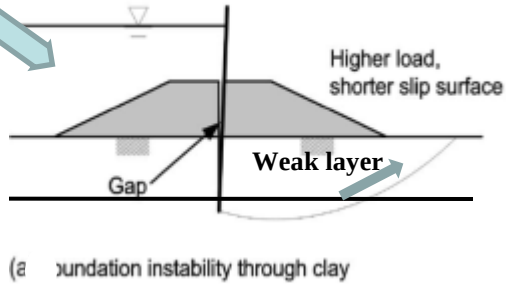


Overview
Failure Mechanisms during Katrina

- **IPET investigated 4 major failure mechanisms**
  - Gap Formation- almost all breaches
  - Piping failure- London Canal Ave. South
  - Shear failure of the weak soil- 17th St. Canal
  - Erosion- IHNC







(Duncan Et al. 2008)

I-Wall/T-Wall

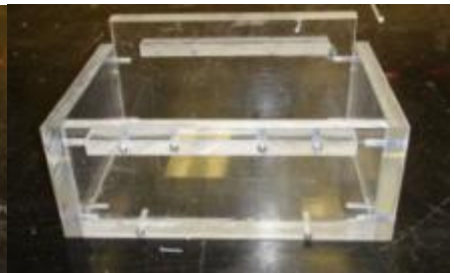
Soil Erosion

- Soil erosion test
- Soil erosion analysis
- Soil erosion countermeasures
  - Erosion energy dissipation structure
  - Developing erosion resistance soils

Soil Erosion

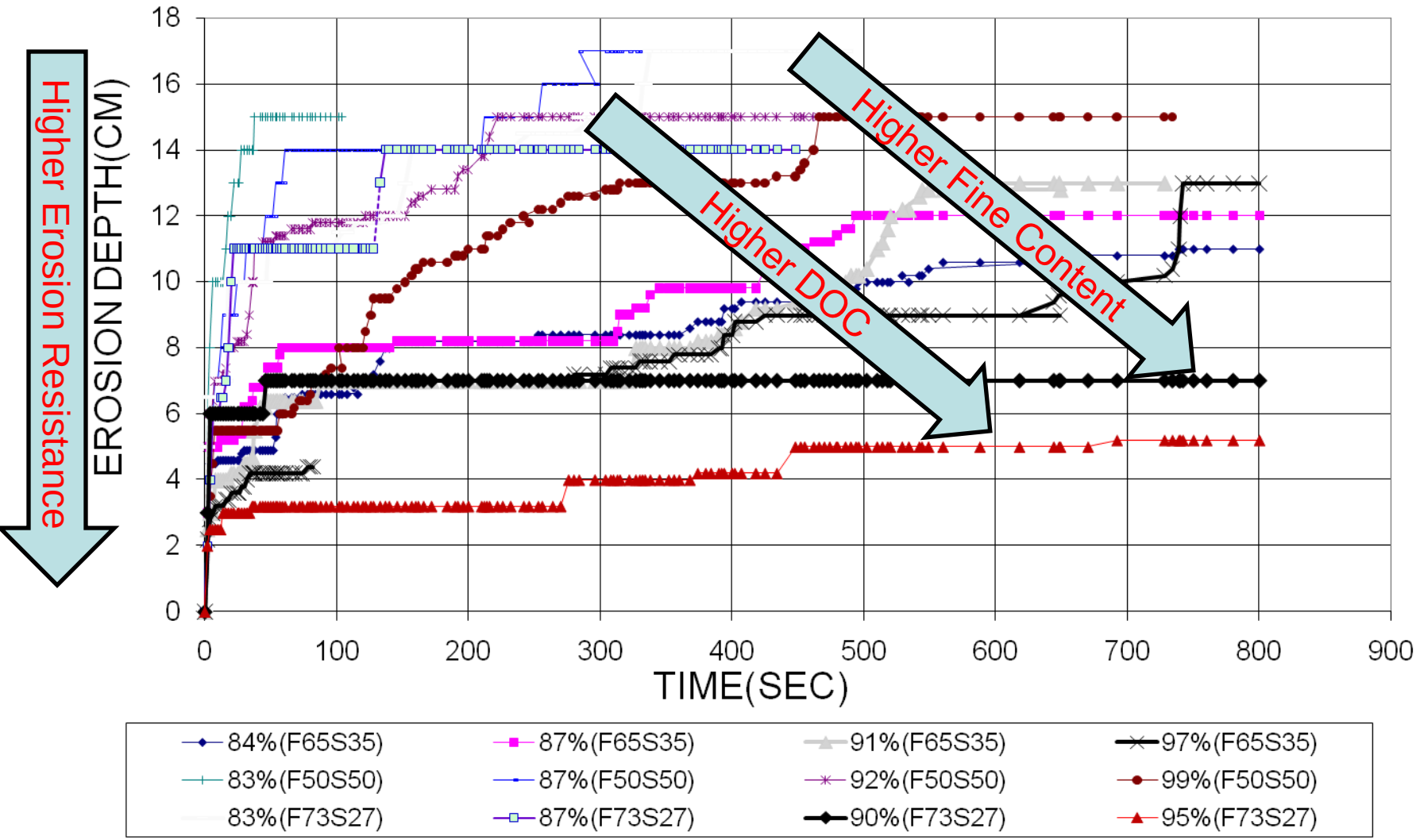
Tests using UM Erosion Test Bed

Adjustable Flow Rate:
2600, …460 k Gal/hr
Adjustable Nozzle Size/Type



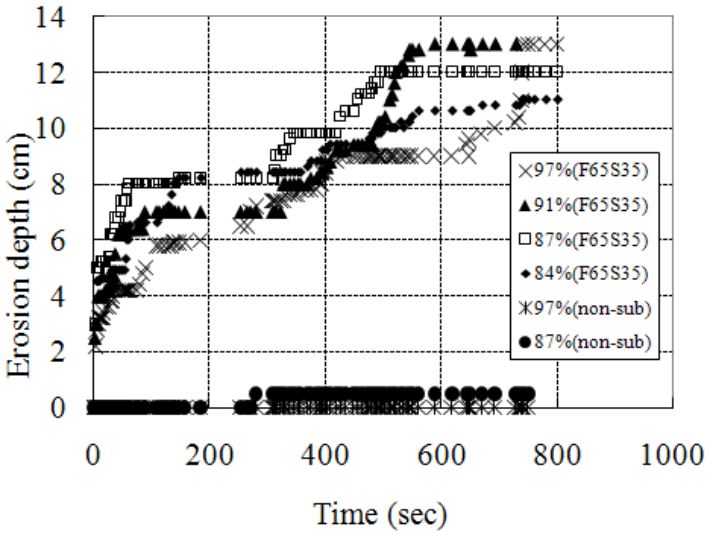
Use a digital video camera to record and analyze the erosion process.

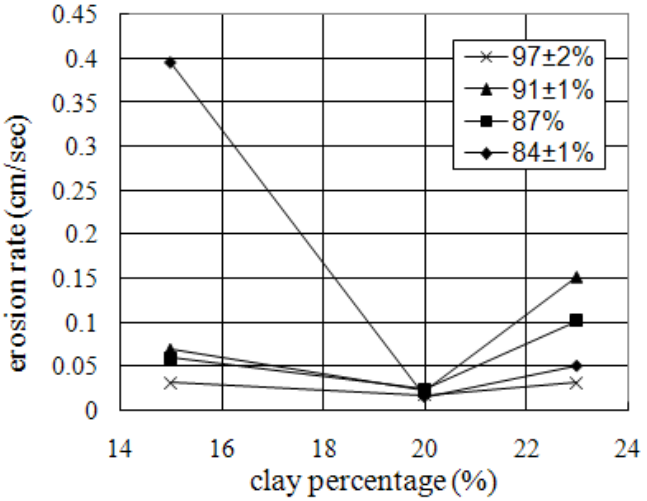
Soil Erosion
(Erosion Test)



Soil Erosion

Erosion resistance of Actual Levee Materials





Soaked soils showed much weaker erosion resistance.

Need to modify test procedure.

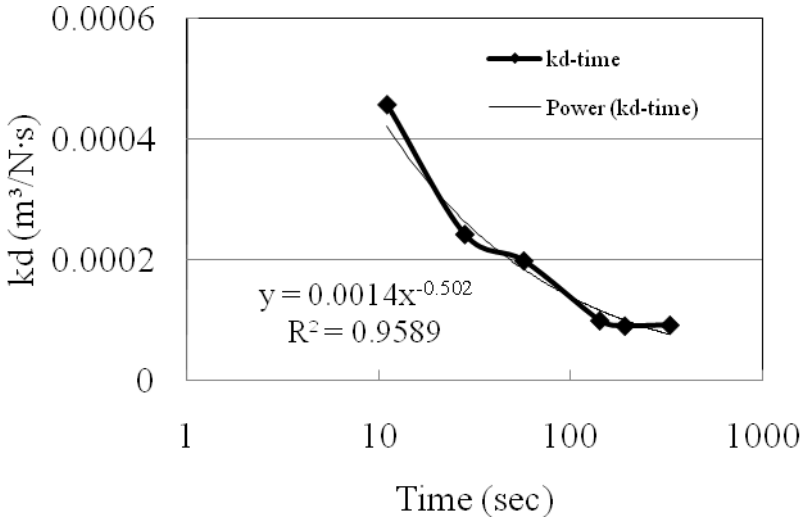
Expansive clay minerals should be avoided!

Higher clay contents do not always increase the erosion resistance.

Critical clay contents concept is needed in Levee material specification.

Soil Erosion

Erosion depth prediction



- Governing Equation

  Excess shear stress concept

$$\frac{dD}{dt} = k_d(\tau_0 \frac{D_p}{D} - \tau_c)$$

Field equation

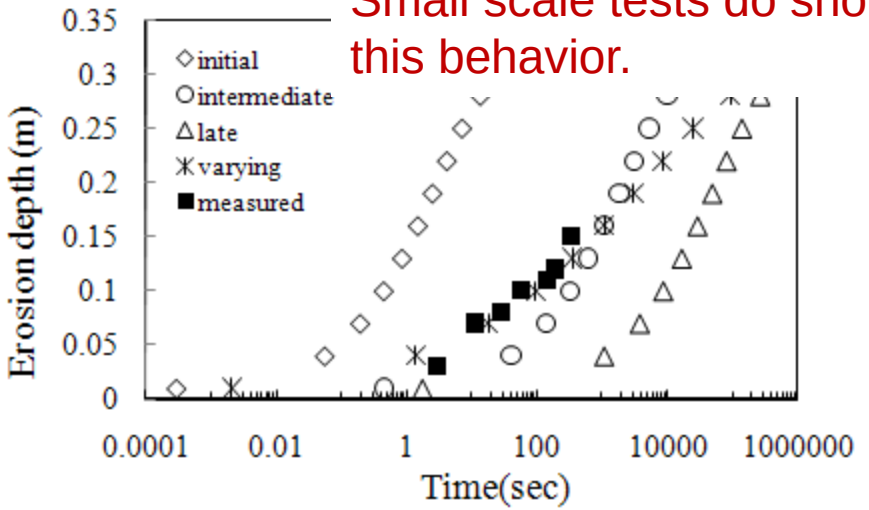
$$t = \left[51.46 \left\{ \frac{21D^2}{2.28 - 6.92D} - \frac{D - 0.0165}{0.33} + \ln\left(\frac{0.3135}{0.33 - D} \right) \right\} \right]^2$$

Erosion coefficient is not a constant!

Small scale tests do show this behavior.

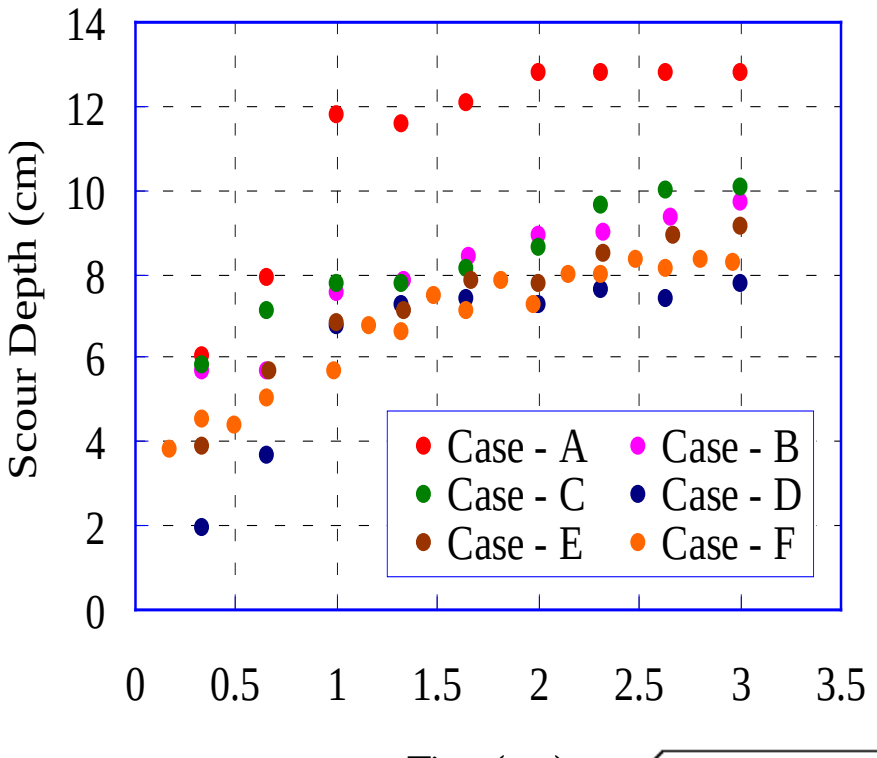
Predicted Erosion Depths at IHNC: 1.3-3.42 m

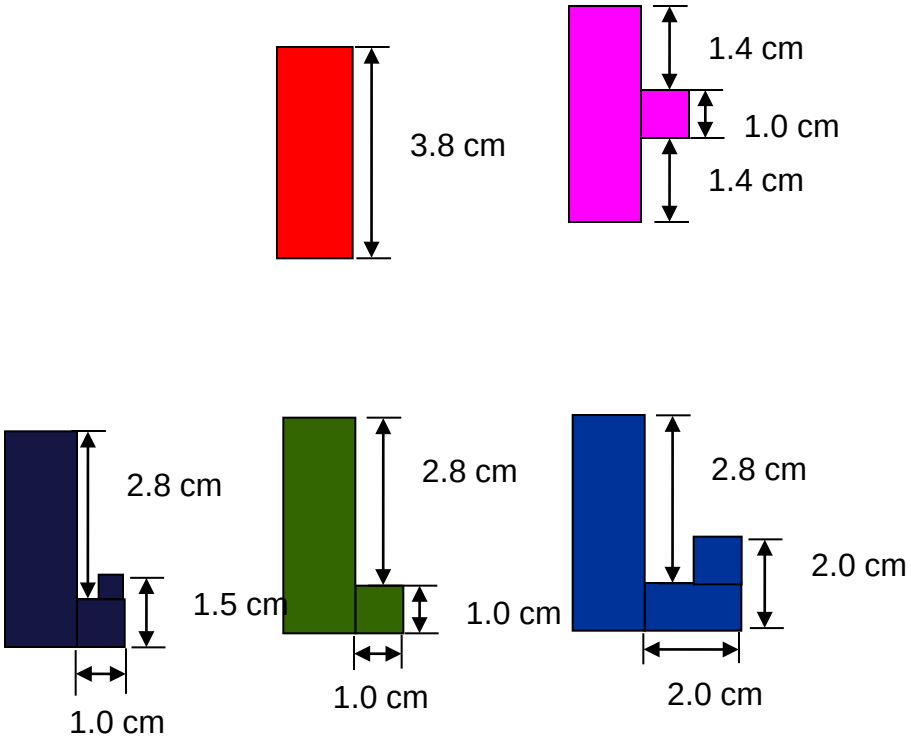
Observed Erosion Depths at IHNC: 1.98-4.57 m



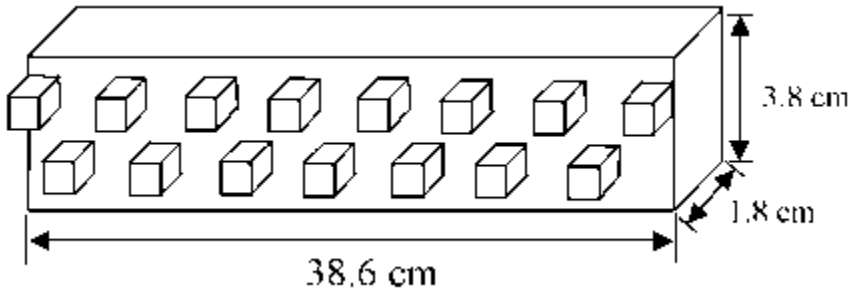
Soil Erosion

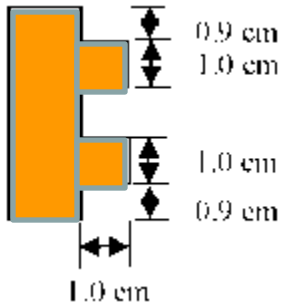
Evaluation of water breaking structure to reduce erosion for ASTM C-109 Ottawa Sand





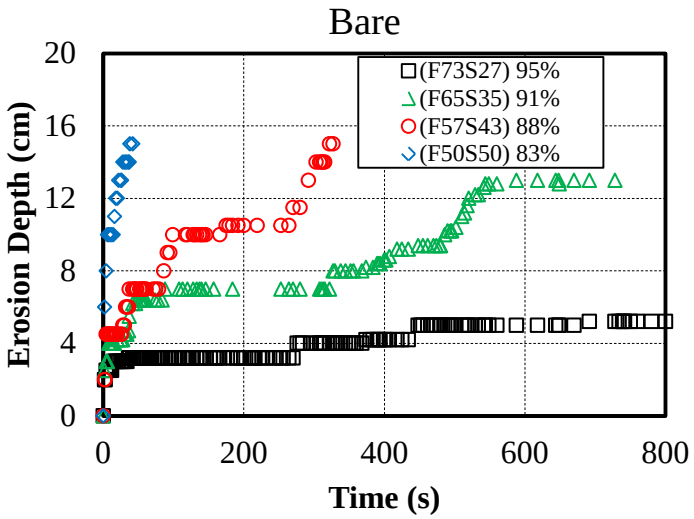
Water breaking structure could reduce the erosion depth as much as 40%, erosion time as much as 400%.

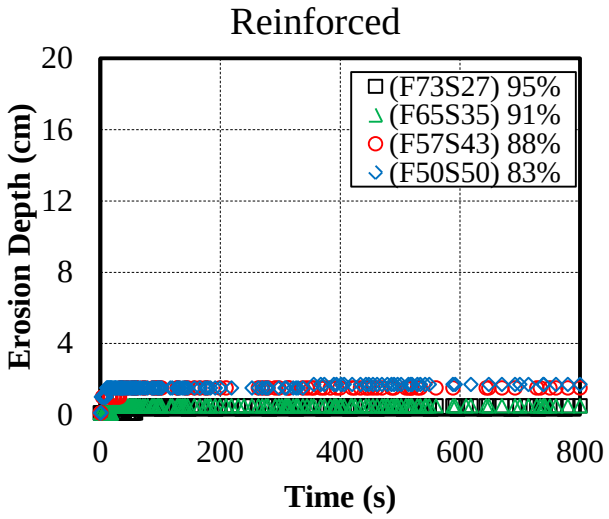




Soil Erosion

Erosion resistant solution: Soil Cement





Swelled

Not-swelled

Soil Erosion

Erosion resistant solution: Vetiver

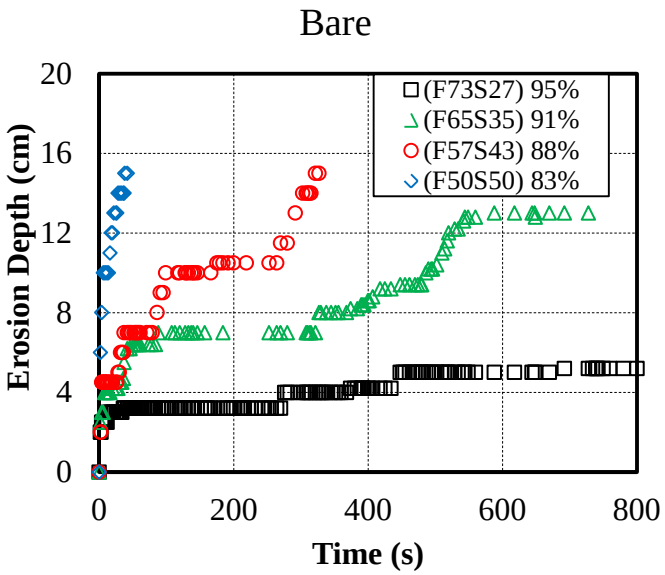
www.vetiver.org

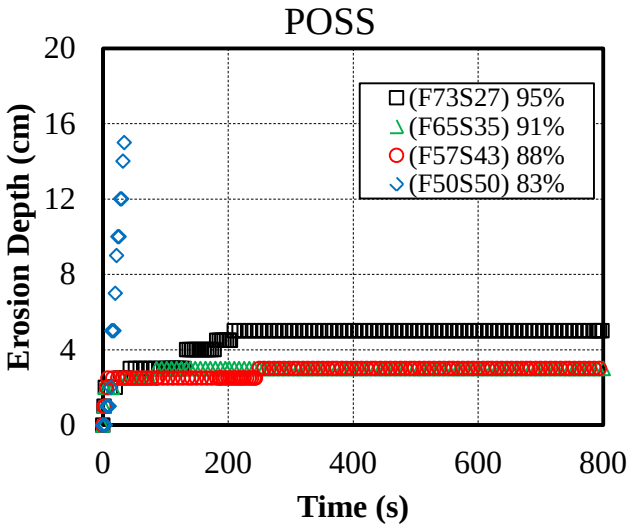
After Before

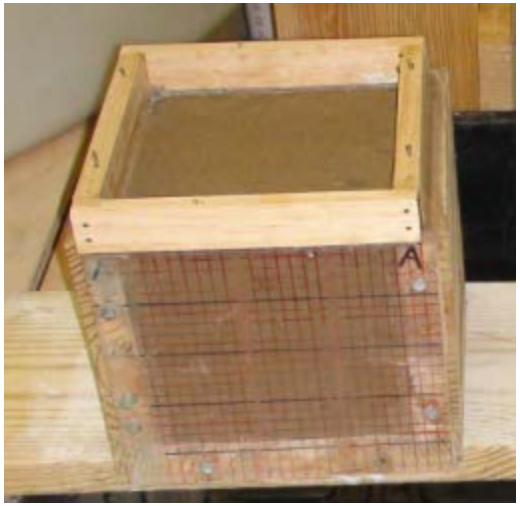
- No erosion at all!

Soil Erosion

Erosion resistant solution: POSS

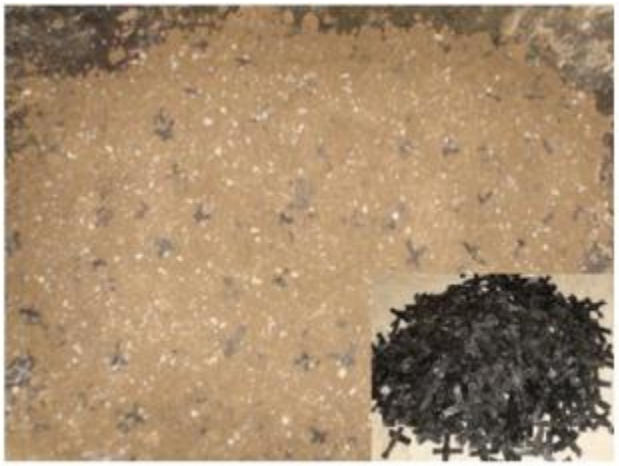




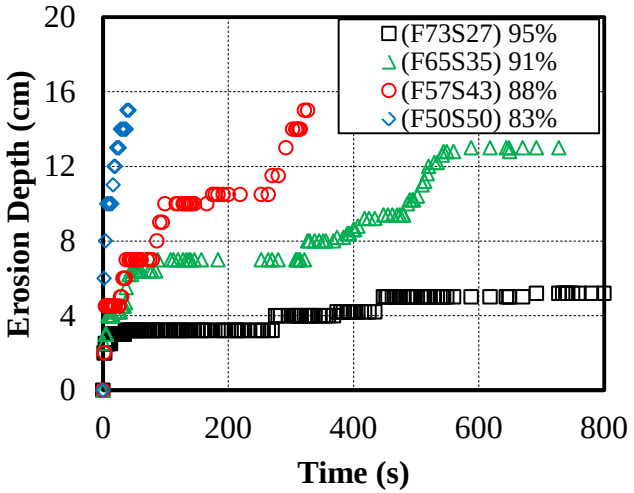


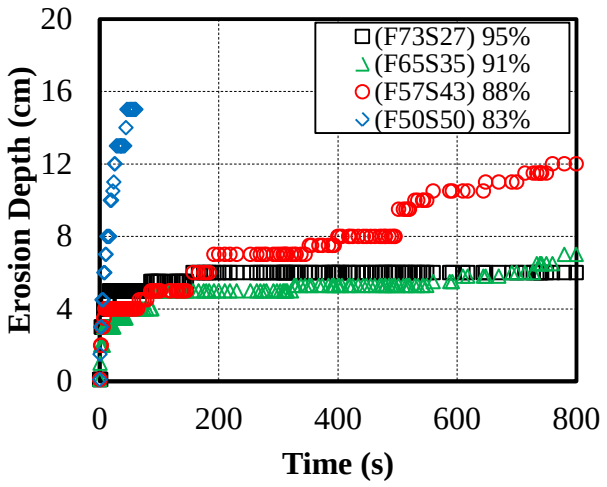
Soil Erosion

Erosion resistant solution: Geotextile



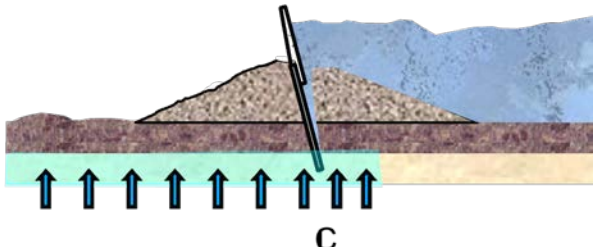
Soil Cement: Need field mixing
Vetiver: Need time to establish the grass
POSS: Need field spraying
Geotextile: Need field mixing



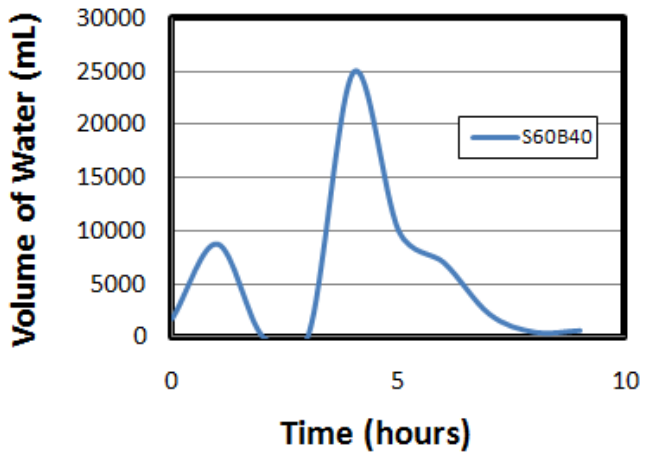


Gap Development/Sealing

Self Sealing Gap Solution

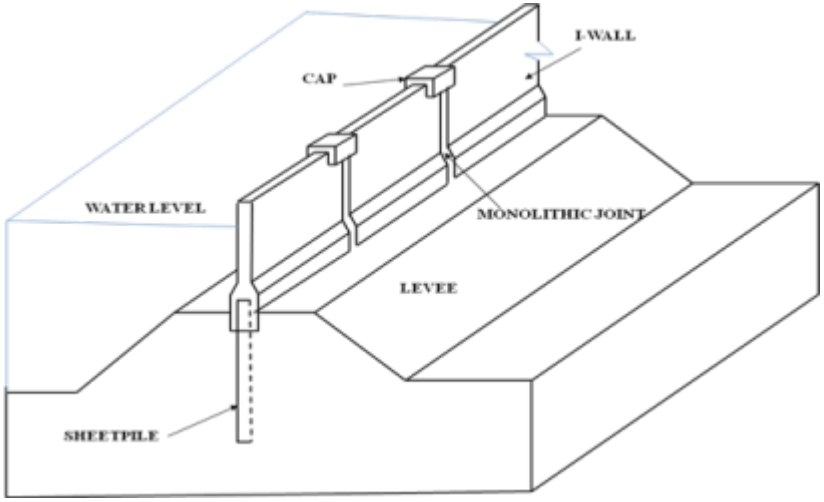


Sand:Bentonite = 60:40



Structual/Material Solutions

Structural Cap



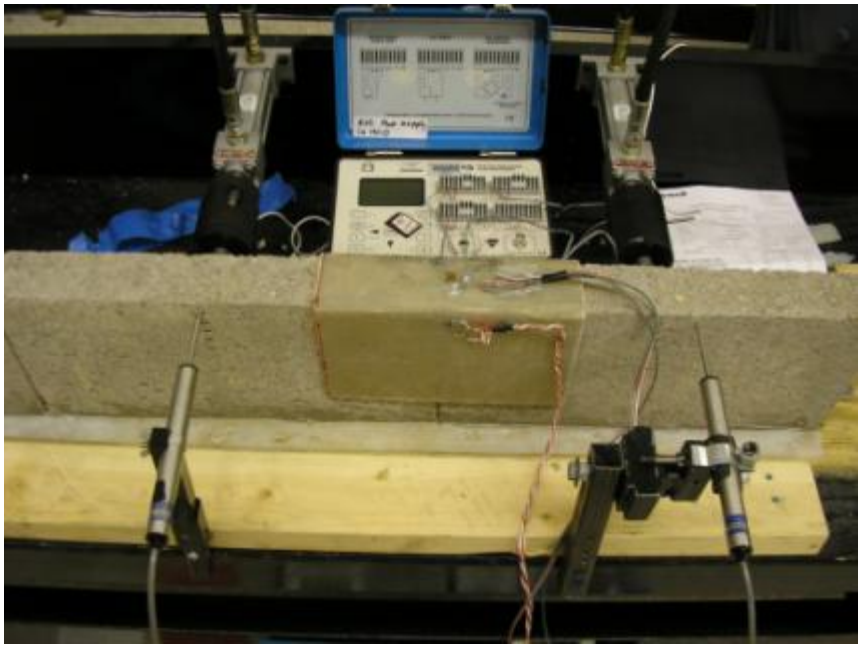
It may be helpful to have connections between walls to prevent such collapse and lateral movement.

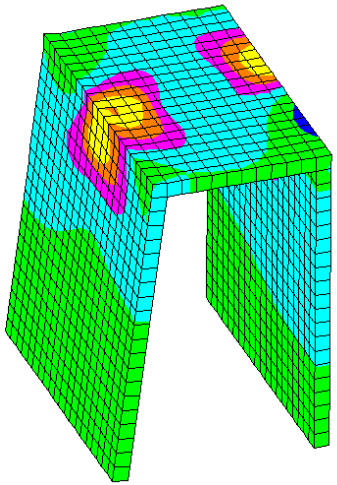
Picture Source: http://www.nytimes.com/2005/09/21/national/nationalspecial/21walls.html

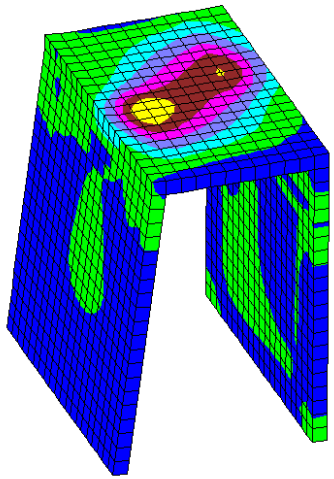
Structual/Material Solutions

Structural Cap

Max Bending: 40 ksf
Max Shear: 120 ksf



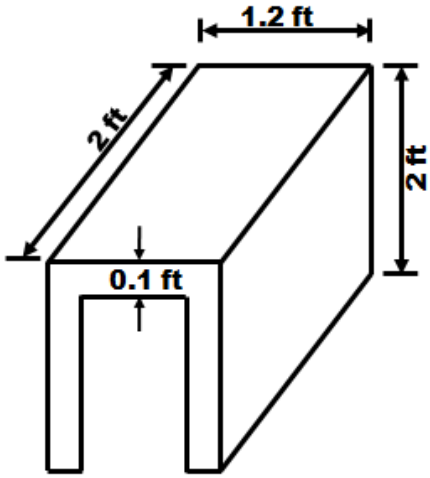




It may be helpful to have connections between walls to prevent such collapse and lateral movement.

So far we got promising results by numerical analysis. Results are under verification.

Tentatively the ideal cap should have following dimension and properties.



EI= 46.2 k-ft^2/ft

Acknowledgement

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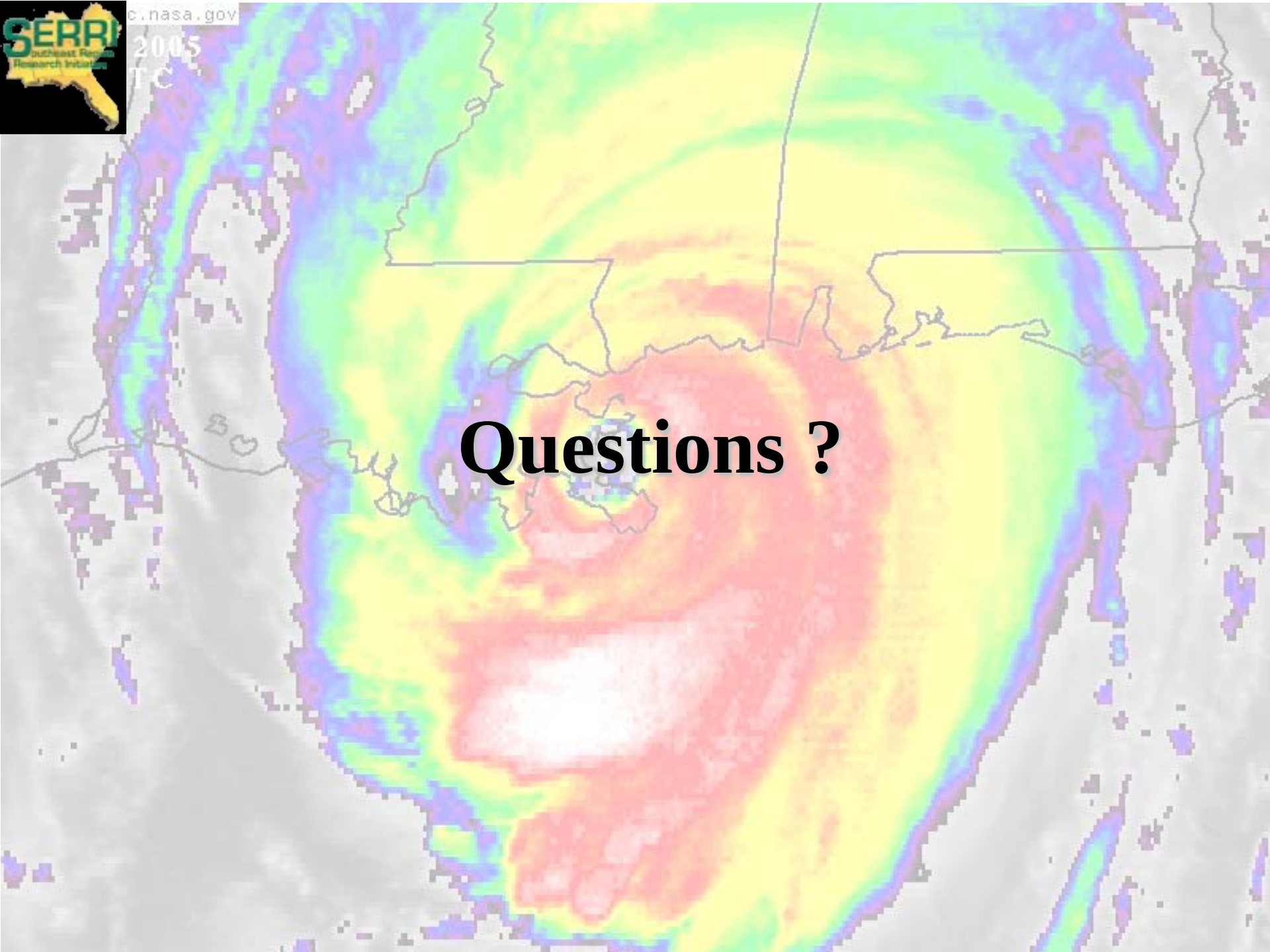
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Questions ?