Experimental Evaluation of Erosion Behavior of New Orleans Levee Materials

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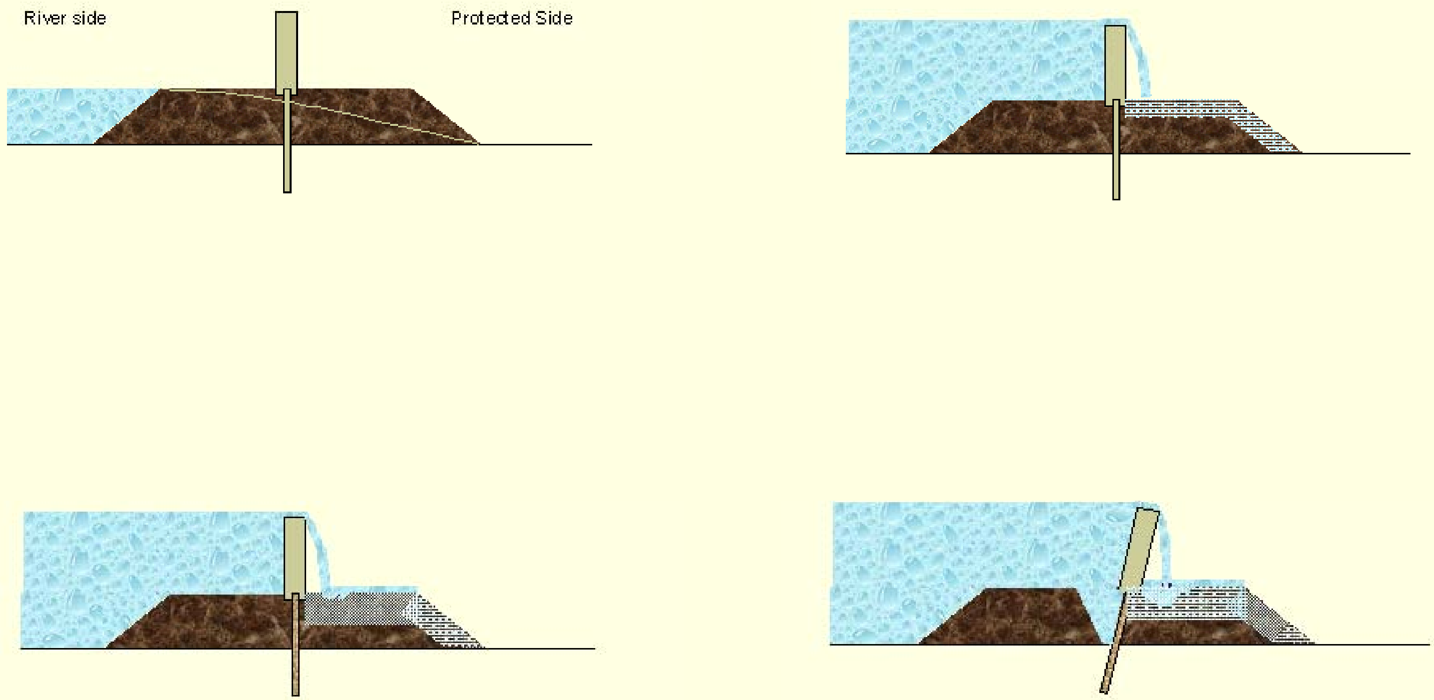
Erosion Mechanism



IPET Report (2008)

Purpose of The Research

- Provide a resilient levee and floodwall system through levee back side protection to minimize erosion caused by overtopping.

(From DHS Proposal, 2007)

Definition of Erosion

- “Sediment transport”

  (Lou,1981; Singh&Scalatos,1985; Fread,1988)
- “Formation and advance of vertical drop or headcut”

  (Dodge, 1988; Al-Qaser,1991; Hahn et al, 2000; Vaskinn et al,2004)

Factors Influencing on Soil Erosion

Identification	Parameters
Category Ⅰ	**Degree of saturation, Properties of erosion fluids, Magnitude of shear stress, Electrostatic force Van der Waals force, Particle sizes in sandy soils.**
Category Ⅱ	**Compaction water content, Clay component**
Category Ⅲ	**Degree of compaction, Percentage of clay**

Typical Current Erosion Test Methods

- RCT (Rotation Cylinder Test)
- HET (Hole Erosion test)
- EFA (Erosion Function Apparatus)
- Flume Test
- Jet Erosion Test

Main Difference between Test Methods

RCT (SS, Lim, 2006)	- Erosion by rotating water on the surface of the soil - Measuring the weight of eroded soils
HET (Chi Fai Wan et al, 2004)	- Erosion by flowing water along the drilled hole of soil - Measuring the change of hole diameter
EFA (Briaud et al, 1999)	- Erosion on flume bed by flowing water - Measuring the eroded length of soil projected on the flume bed
Flume Test (A. Shaikh et al, 1988)	- Erosion on the flume bed by flowing water - Measuring the eroded weight of soil on the flume bed
Jet Erosion Test (G, Hanson et al, 2004)	- Erosion by vertical water jet - measuring the eroded depth

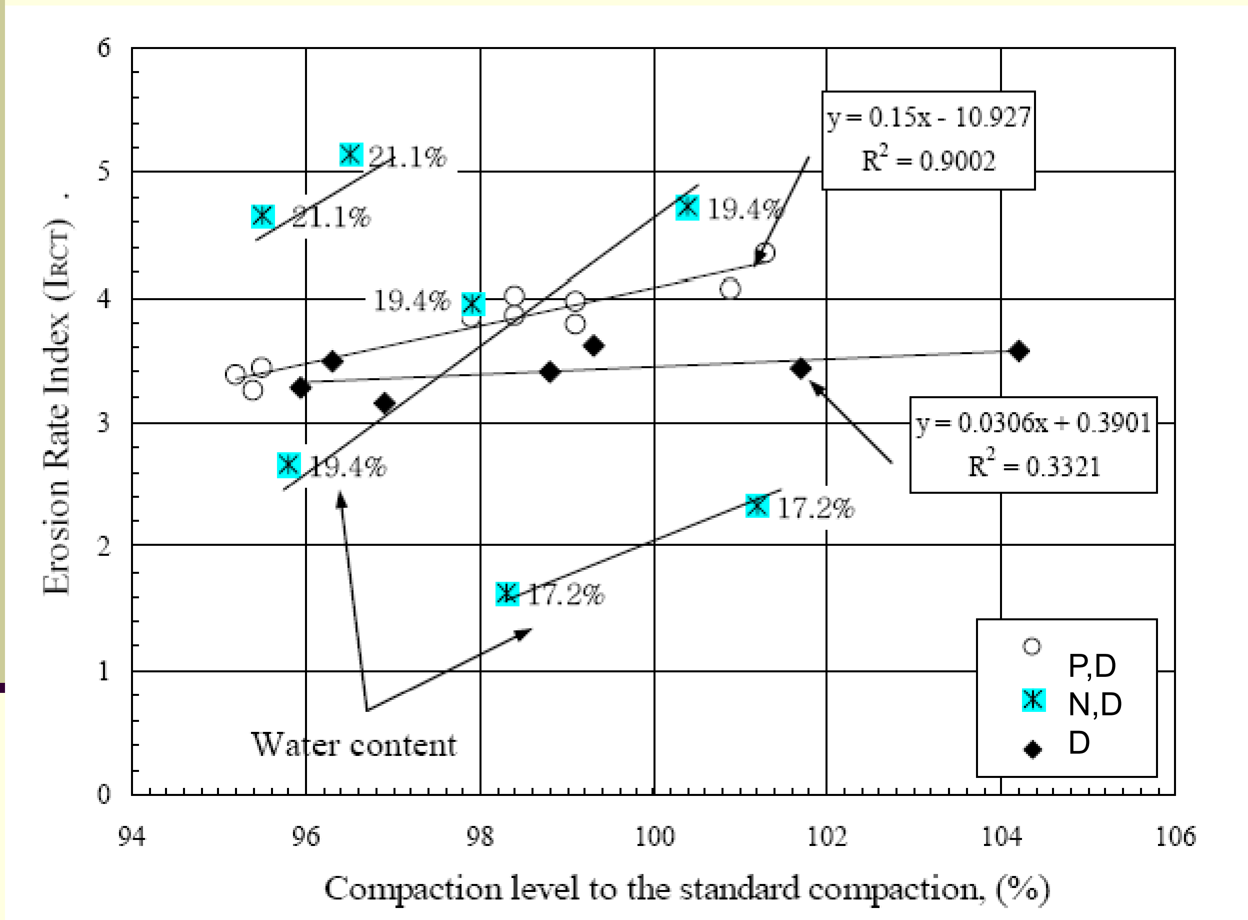
Limitation of Current Erosion Test Methods

- They do not simulate the erosion initiated by vertically plunging water (P)
- Tests were not performed with the saturated soil samples identical to field levee condition under heavy rain. (S)
- Most tests do not consider dispersive soil condition (D)

Dispersion

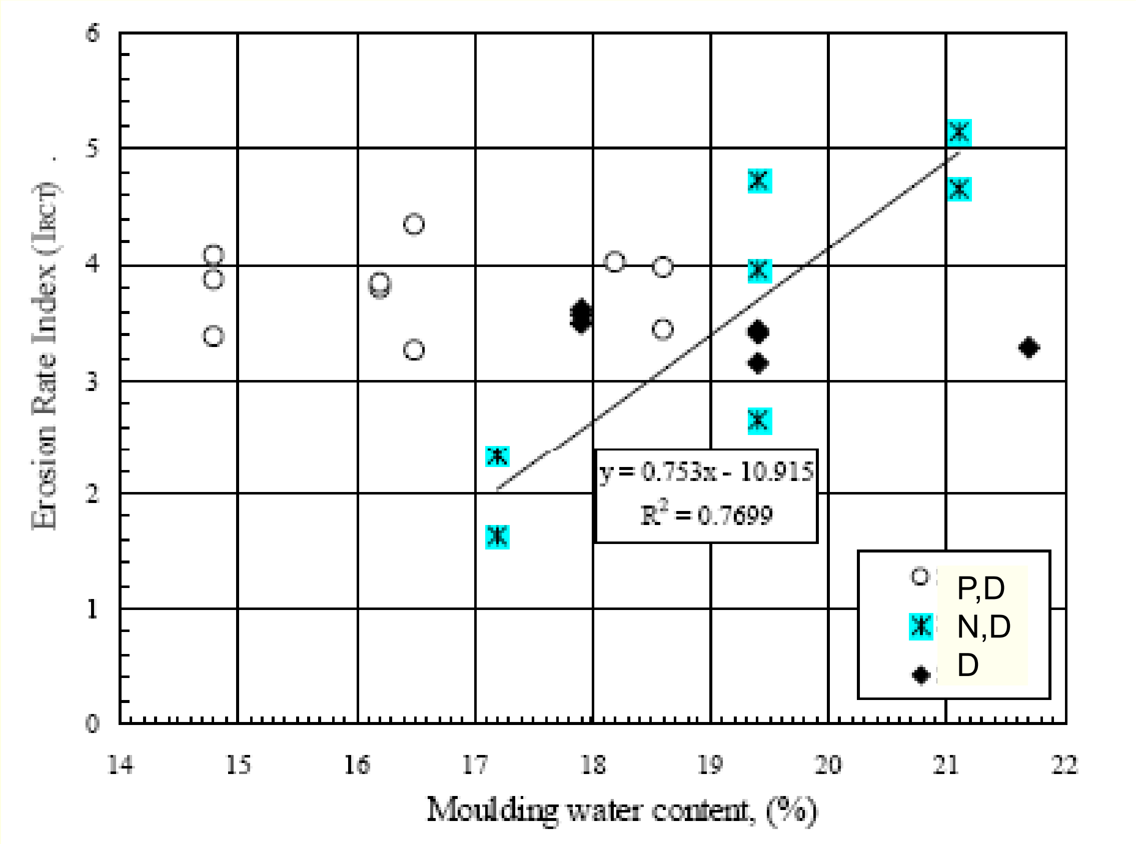
- " A process in which the individual colloidal clay particles go into suspension in practically still water." (By Sherard et al 1976a)
- It means that the erosion of soil can occur even at "zero shear stress" if a dispersive soil remain under water for some time.
- It strongly governs the erosion behavior of soil

Dispersive VS Non-dispersive



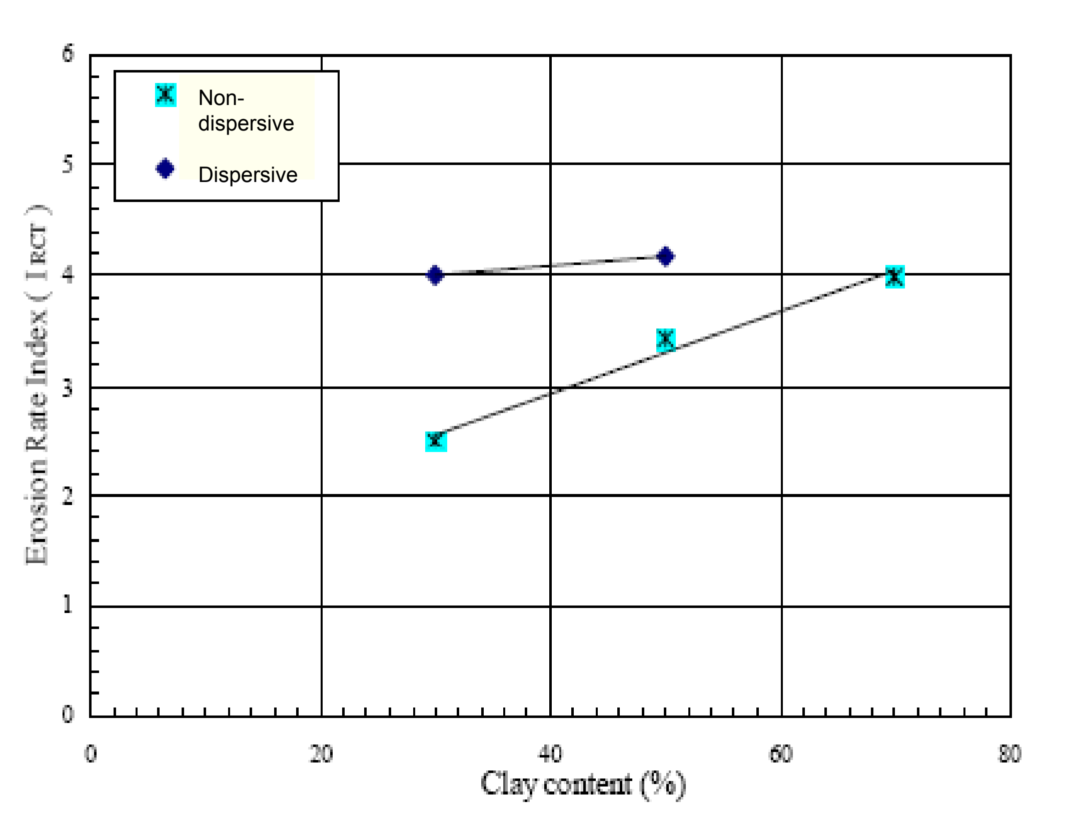
SS Lim (2006)

Dispersive VS Non-dispersive



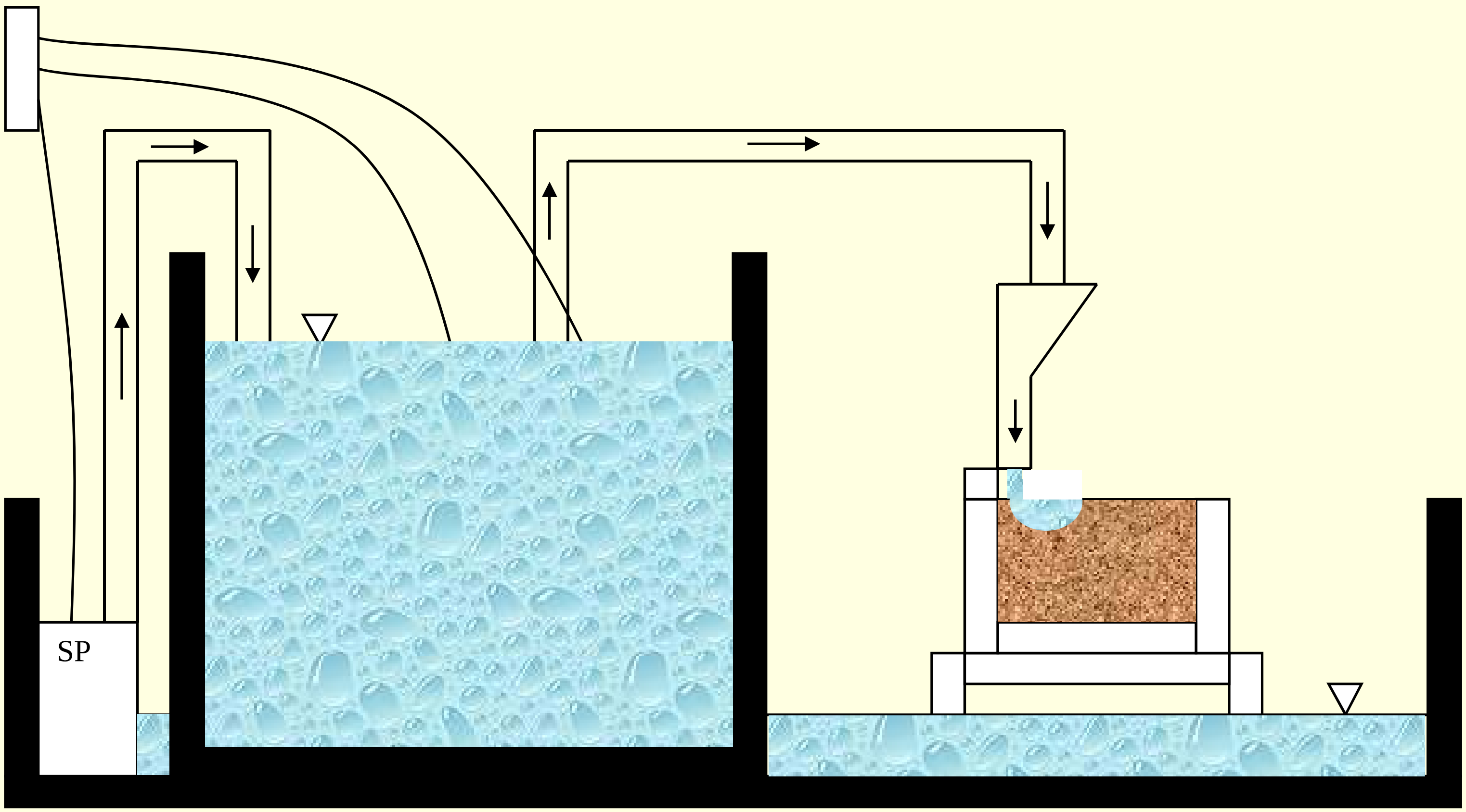
SS Lim (2006)

Dispersive VS Non-dispersive



SS Lim (2006)

UMETB (University of Mississippi Erosion Testing Bed)




EXIT

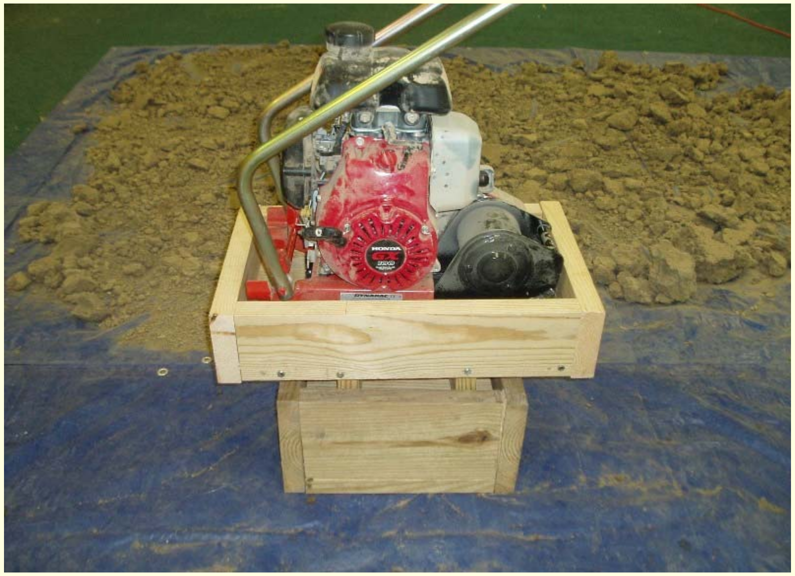
Sample Preparation

- Standard Compaction Test

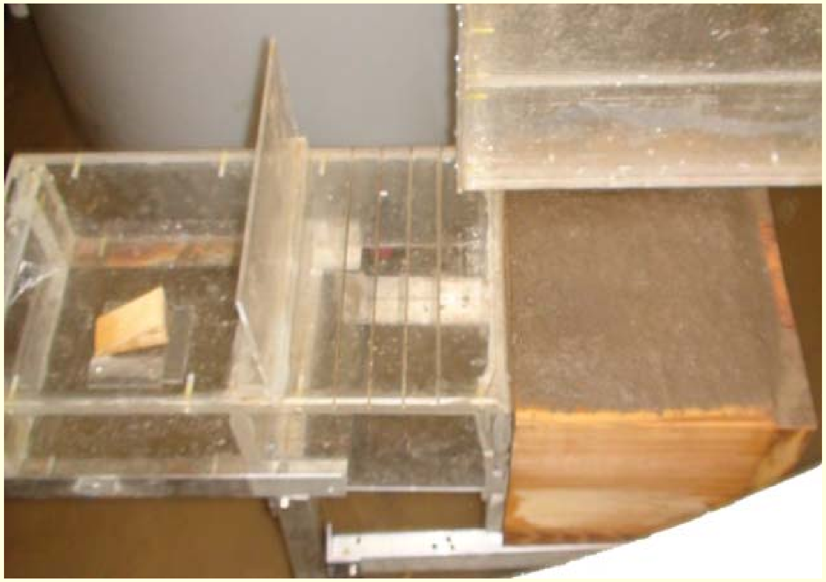
  → MDD (Maximum Dry Density),

  → OWC (Optimum Water Content)
- Mix soils and water at OWC
- Compact soil in the specially fabricated erosion mold at desired DOC
- Submerge erosion molds for two days to simulate the soil condition exposed to heavy rain.
- Soils and boxes are weighed in every stage

Sample preparation





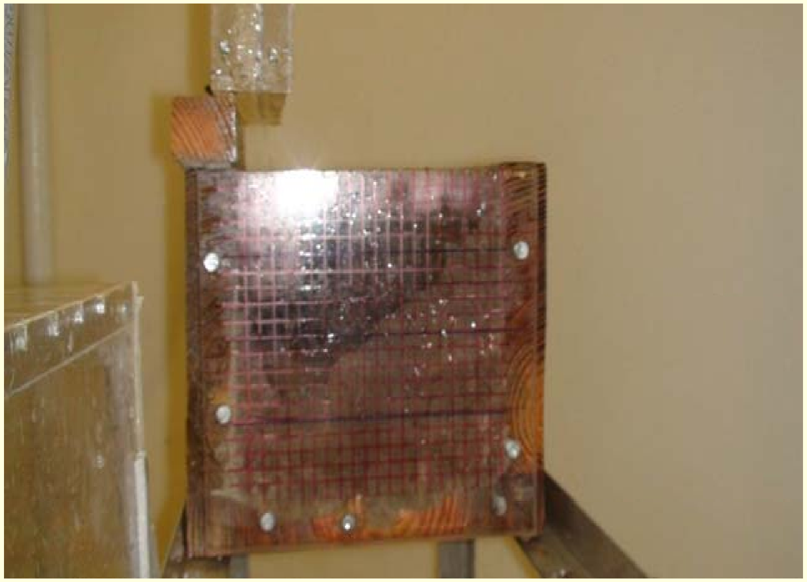



Samples

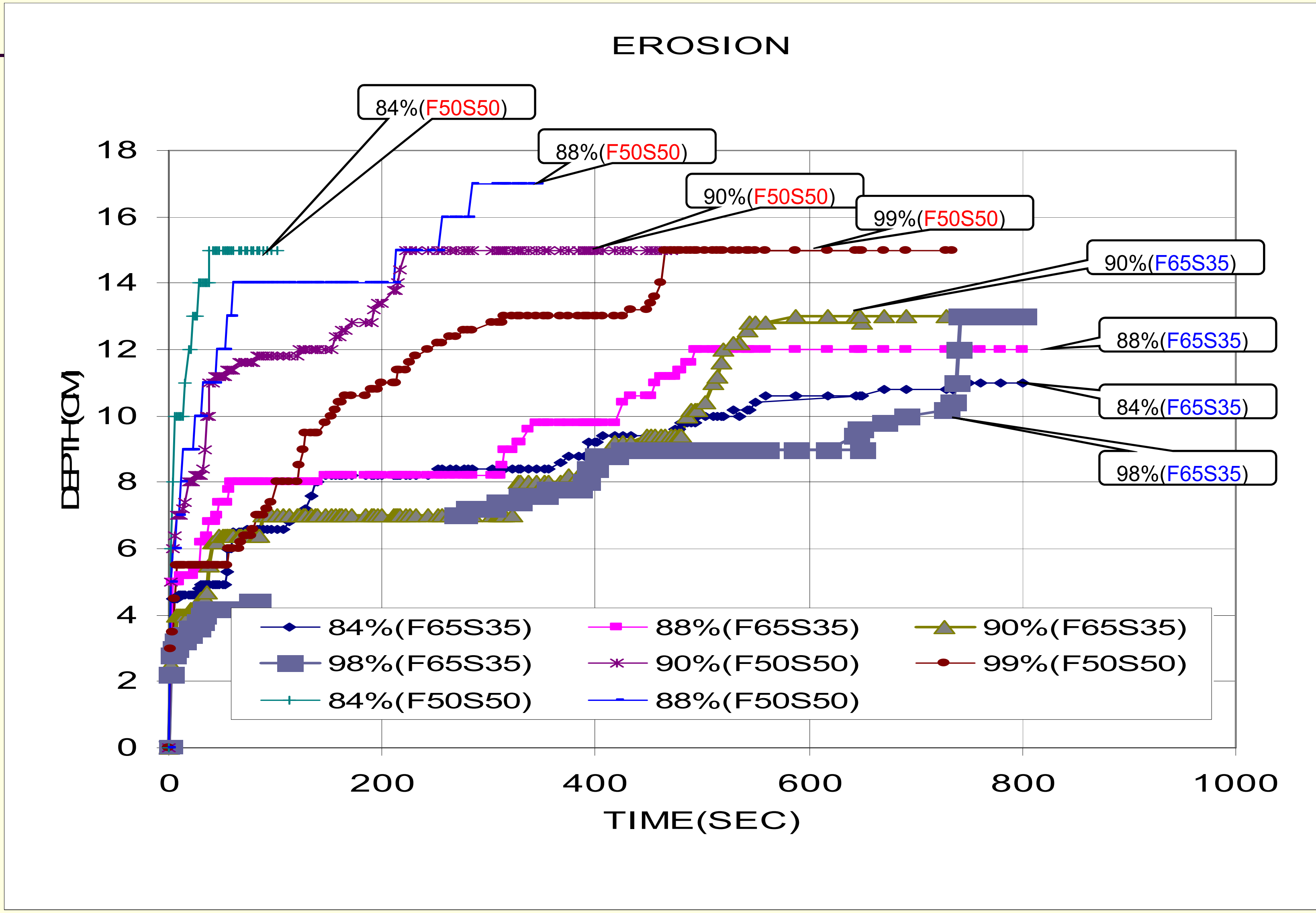
Identification	Mixed Ratio	Degree of Compaction(%)
F50S50	Clay 15%	83
	Silt 35%	87
	Sand 50%	92
		99
F65S35	Clay 20%	84
	Silt 45%	87
	Sand 35%	91
		97
F73S27	Clay 23%	83
	Silt 50%	87
	Sand 27%	90
		95

Identification	Mixed Ratio	Degree of Compaction(%)
K10S90	Kaolinite 10% and Sand 90%	87
		96
K20S80	Kaolinite 20% and Sand 80%	86
		97
K30S70	Kaolinite 30% and Sand 70%	86
		95

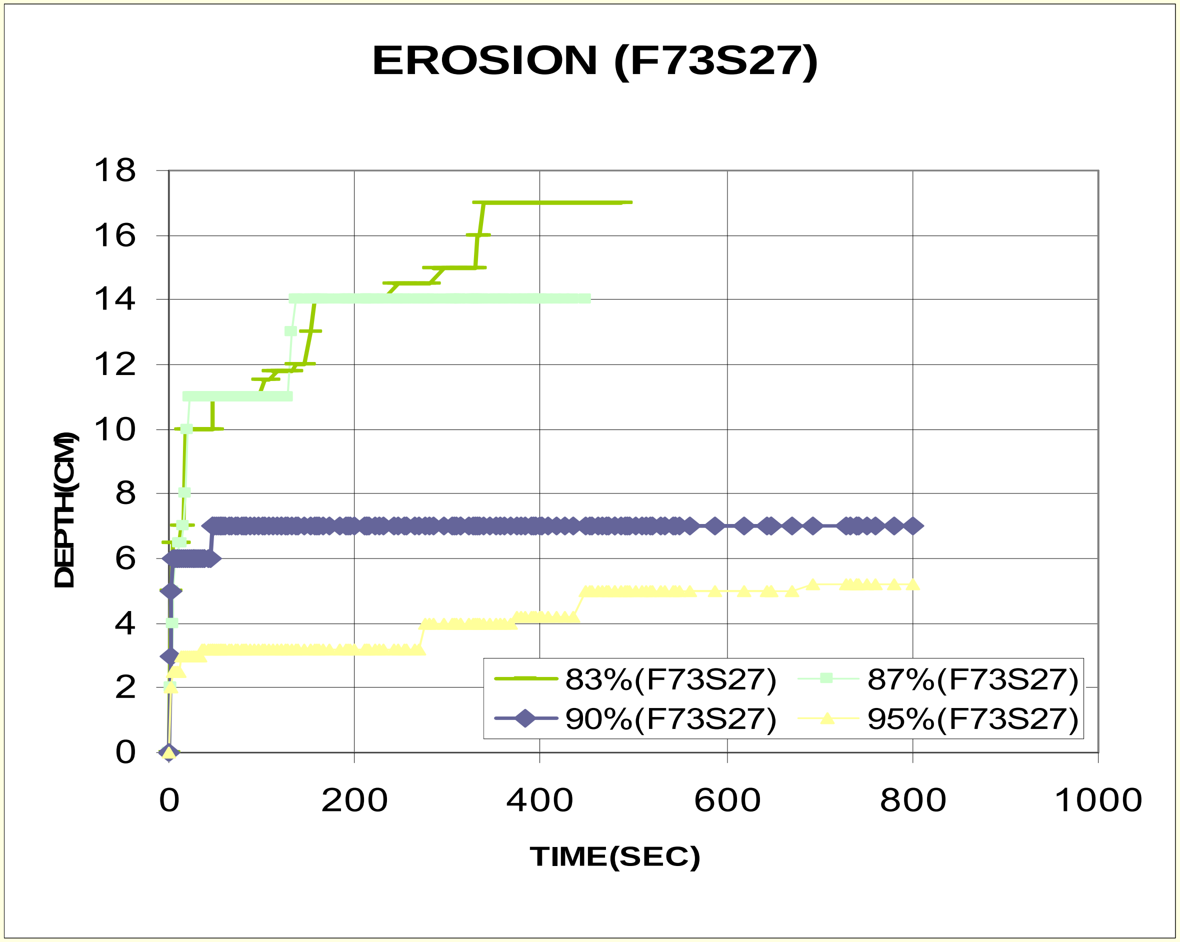

5
10
15



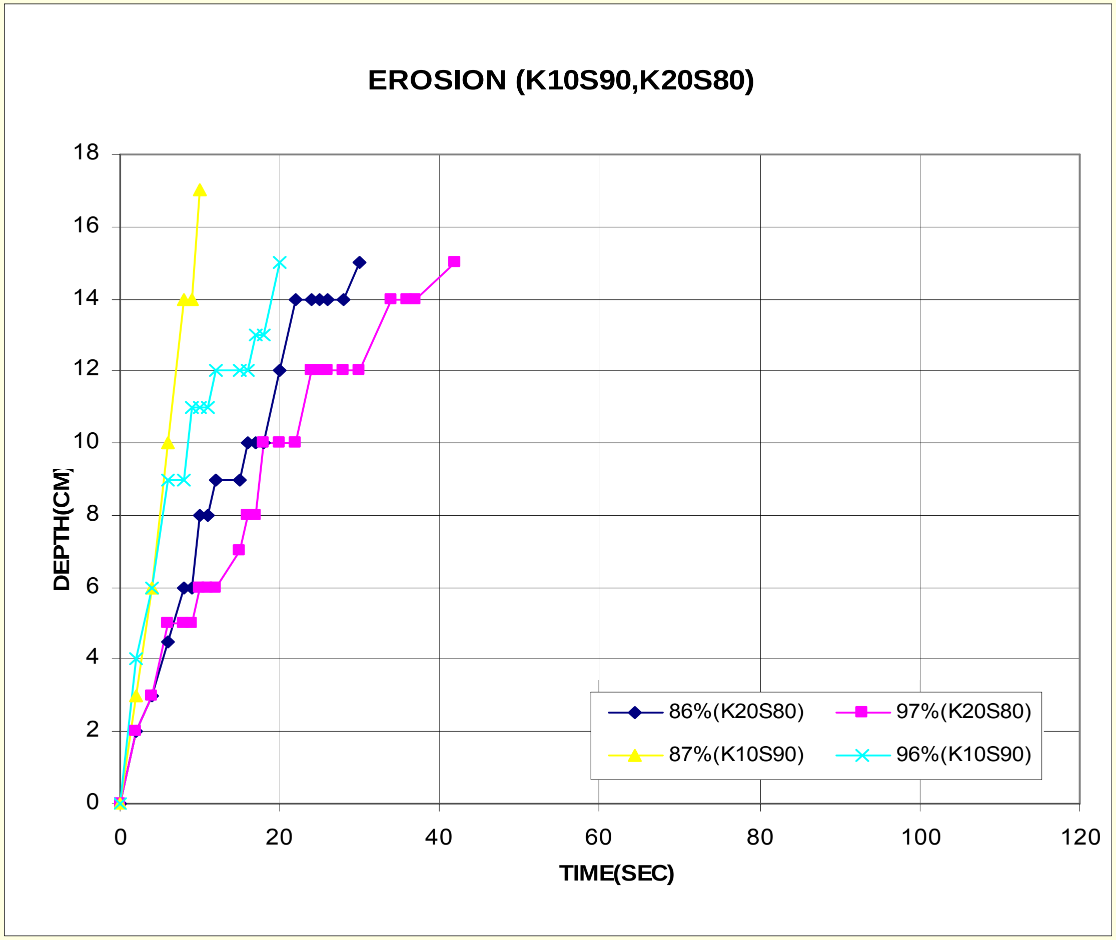
Test Result (F65S35,F50S50)



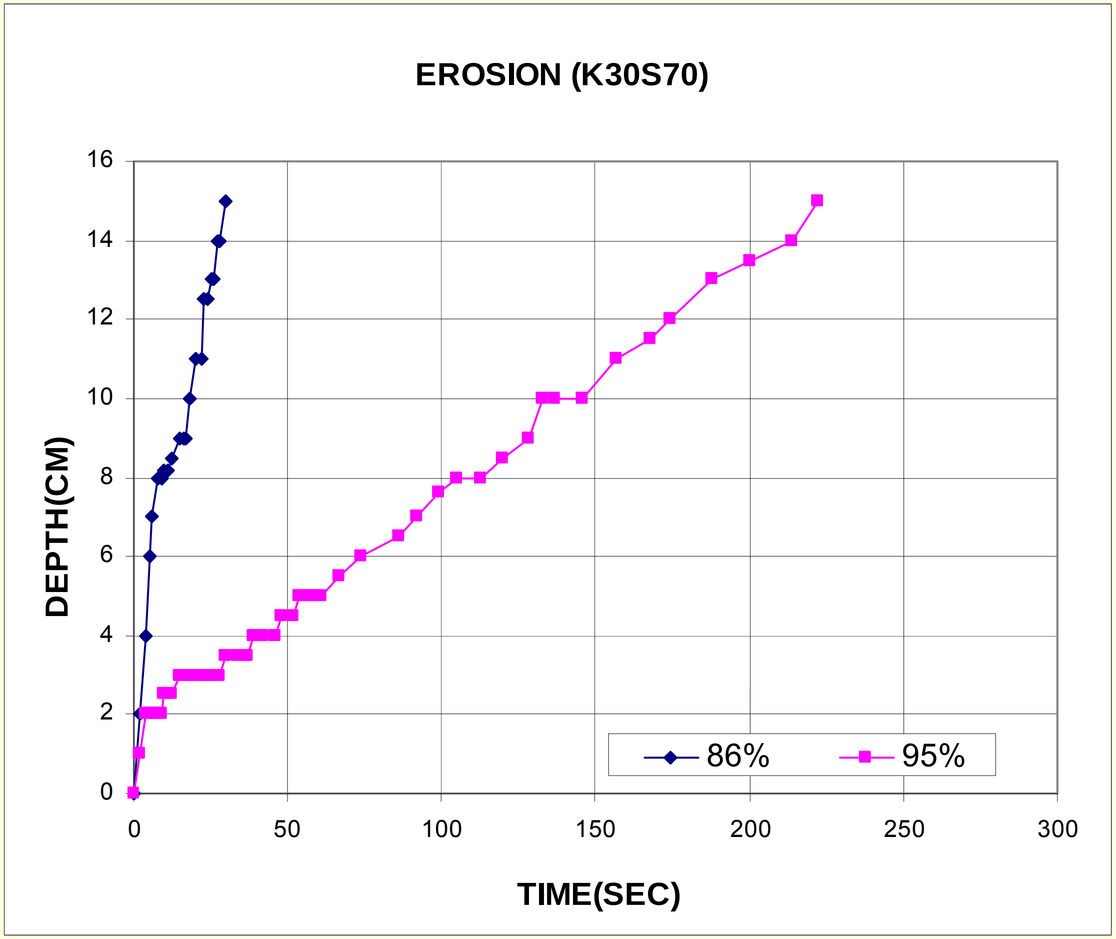
Test Result (F73S27)



Test Result (K10S90,K20S80)

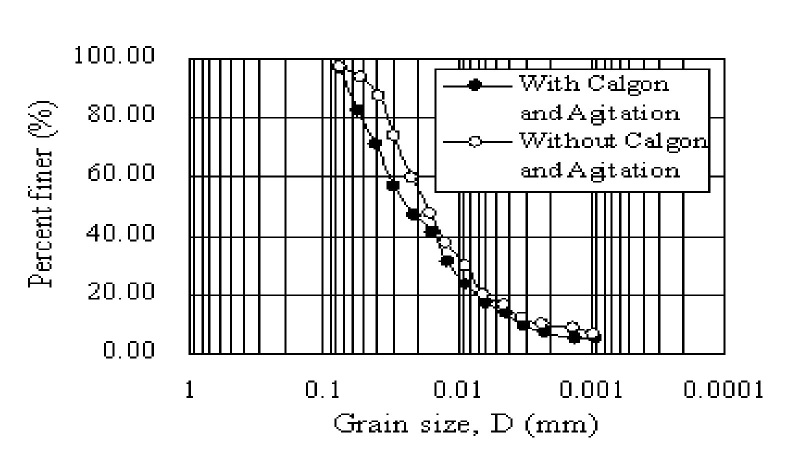


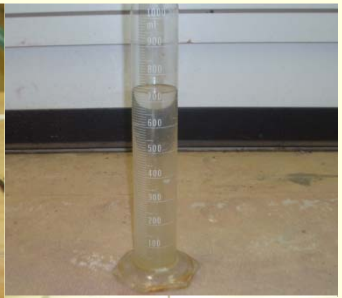
Test Result (K30S70)



Dispersive Test Results

- Double Hydrometer Test (70%)
- Pin Hole Test (Intermediate without hole diameter change)
- X-ray Diffraction Analysis (10% expansive minerals)
- Partially dispersive soil





Conclusion

1. Increasing the clay percentage rather than increasing DOC is much more effective way of increasing the erosion resistance for for 15% of clay mixtures (F50S50).
2. Even though, the clay percentage is increased, higher degree of compaction does not necessarily cause higher erosion resistance for 20%of clay mixture (F65S35).
3. For 23% of clay mixtures (F73S27), even though the clay percentage is increased to enhance erosion resistance, if soil mixtures have high void ratios, the soils shows low erosion resistance.
4. It seems that critical void ratio, which plays a key role in clay soils erosion, is present between 20% and 25% of clay percentages. (Same result in Kaolinite mixtures)

Conclusion

5. For Kaolinite mixtures, K10S90, K20S80, K30S70, enhancing both degree of compaction and clay percentage are effective ways to increase erosion resistance.
6. Based on the result of X-ray Diffraction, Pin Hole and Double Hydrometer Tests, the tested fine-grained soils from the New Orleans quarry site were classified as partially dispersive soils.

Future Work

- Evaluate critical void ratio in clay soils.
- Evaluate nozzle size effect

  - 3mm (current)
  - 6mm
  - 12mm

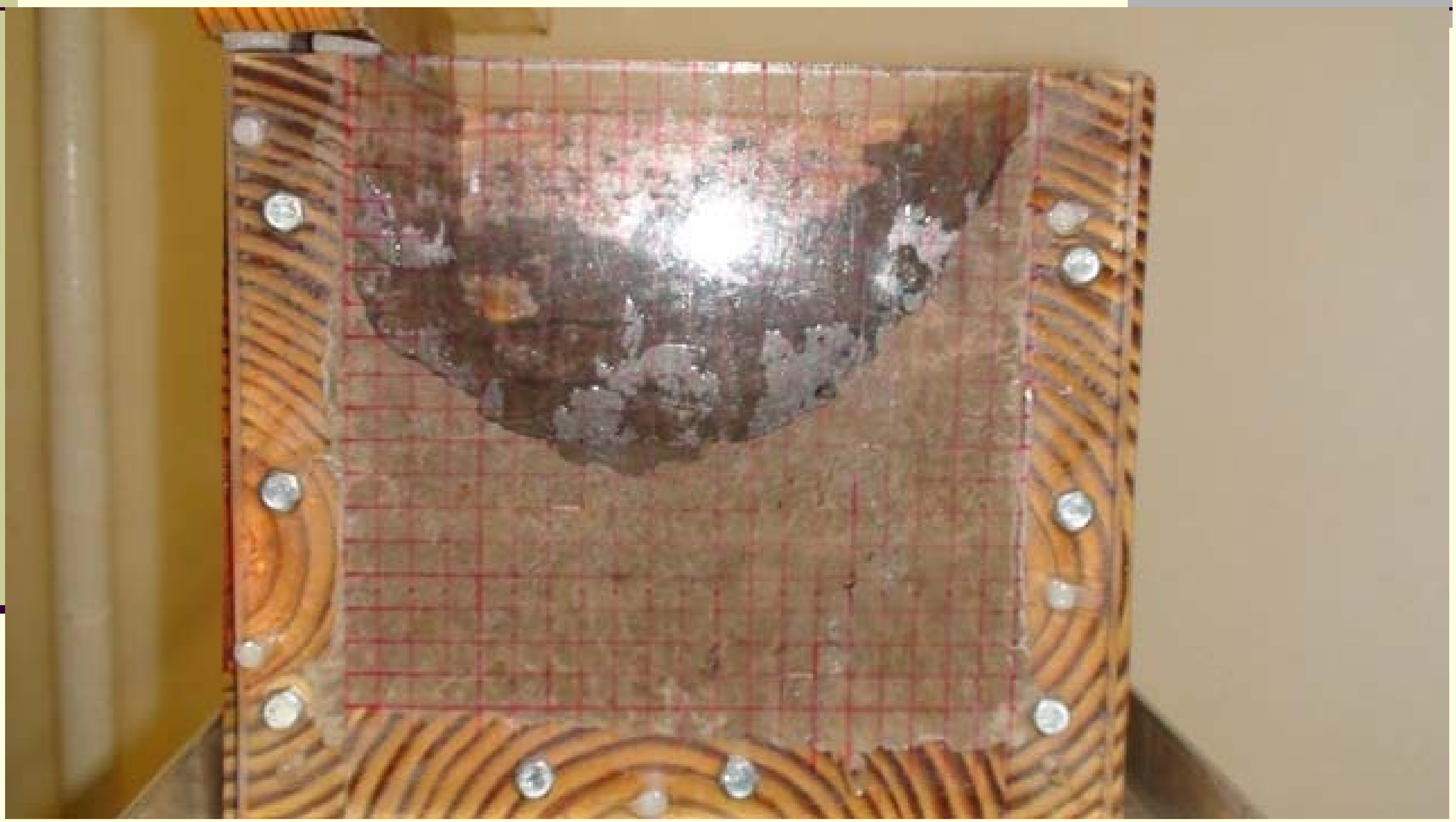
- Estimate plunging water velocity effect

  - 6m/sec (current, 6ft)
  - 8m/sec (11ft)

- Thanks !
- Any Question?

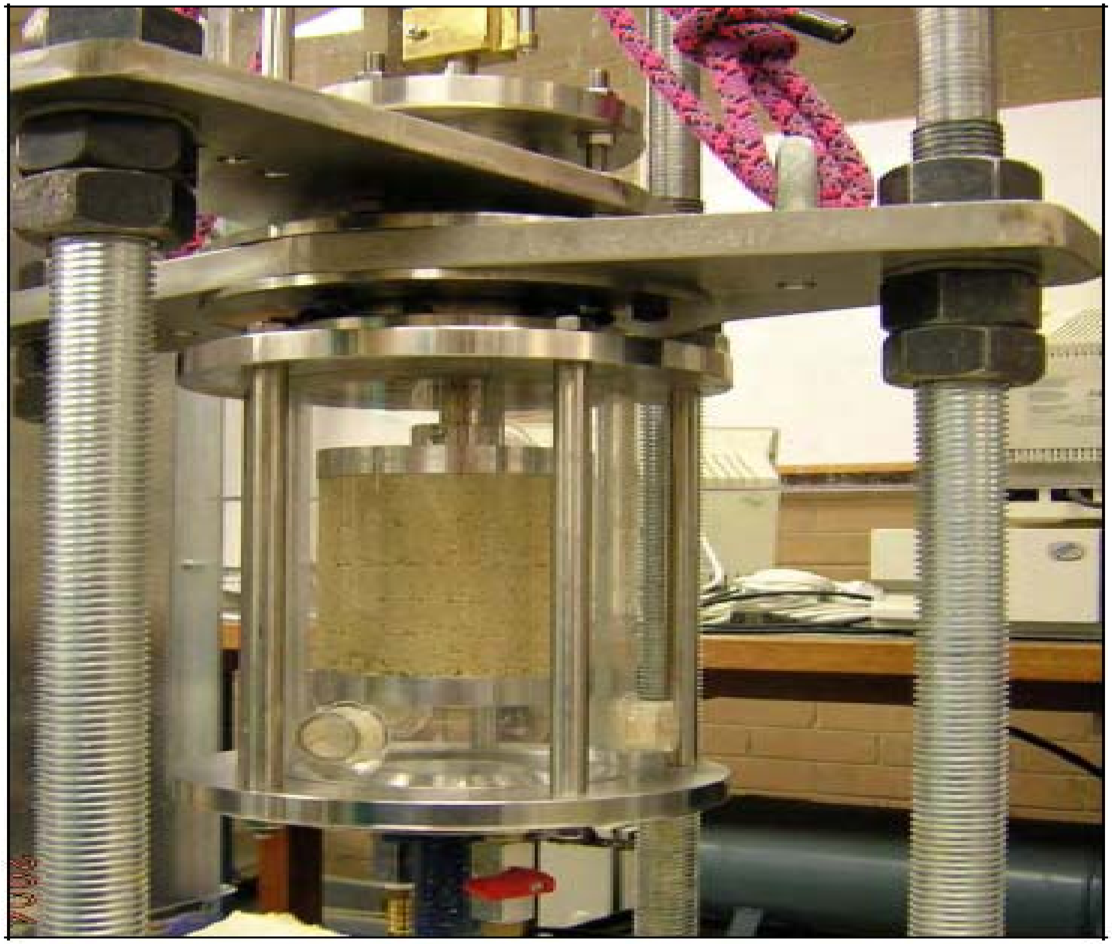
- **Acknowledgement**

This project was sponsored by the DHS (Department of Homeland Security) through SERRI (South East Region Research Initiative) program.



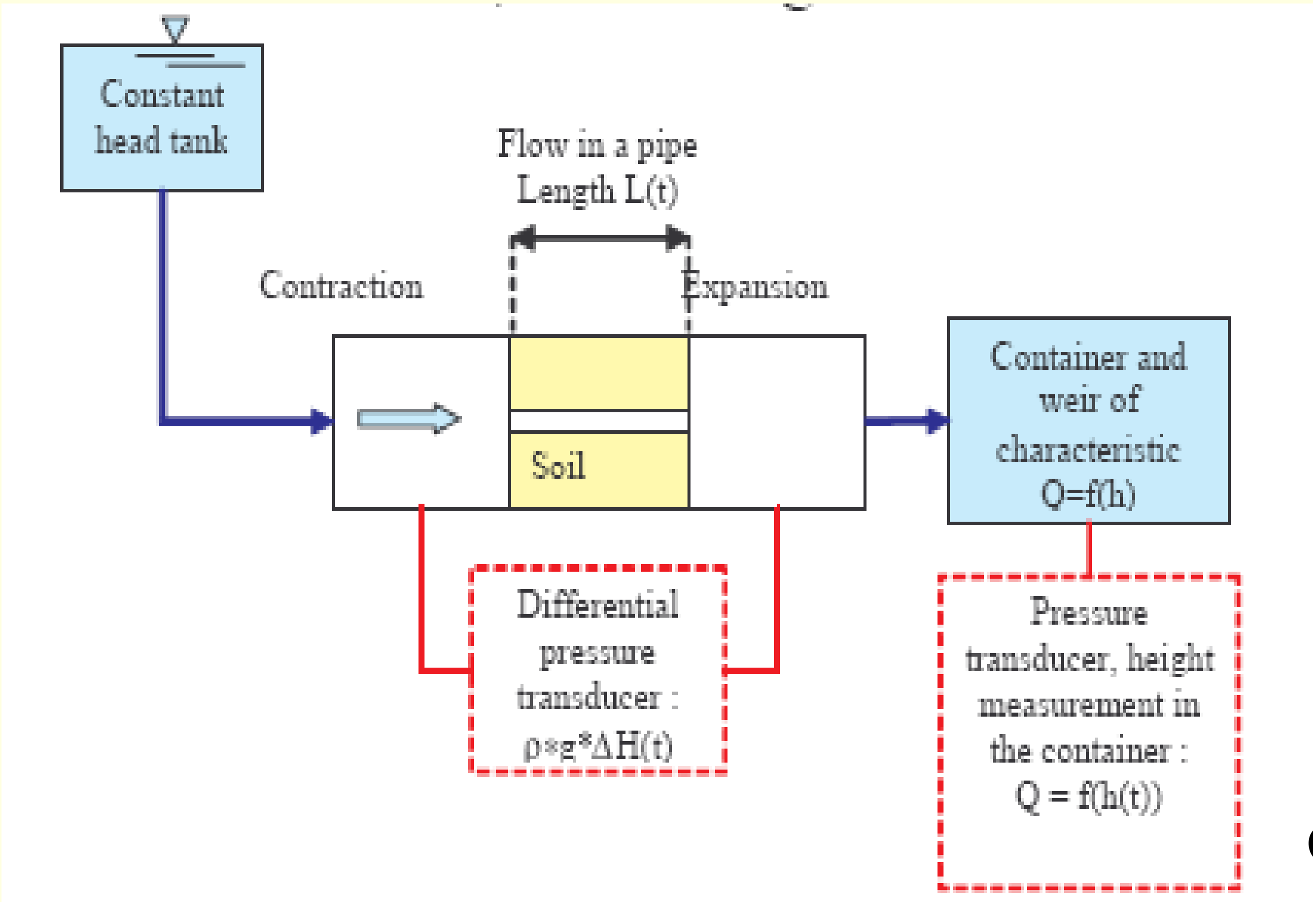

B

RCT (Rotation Cylinder Test)



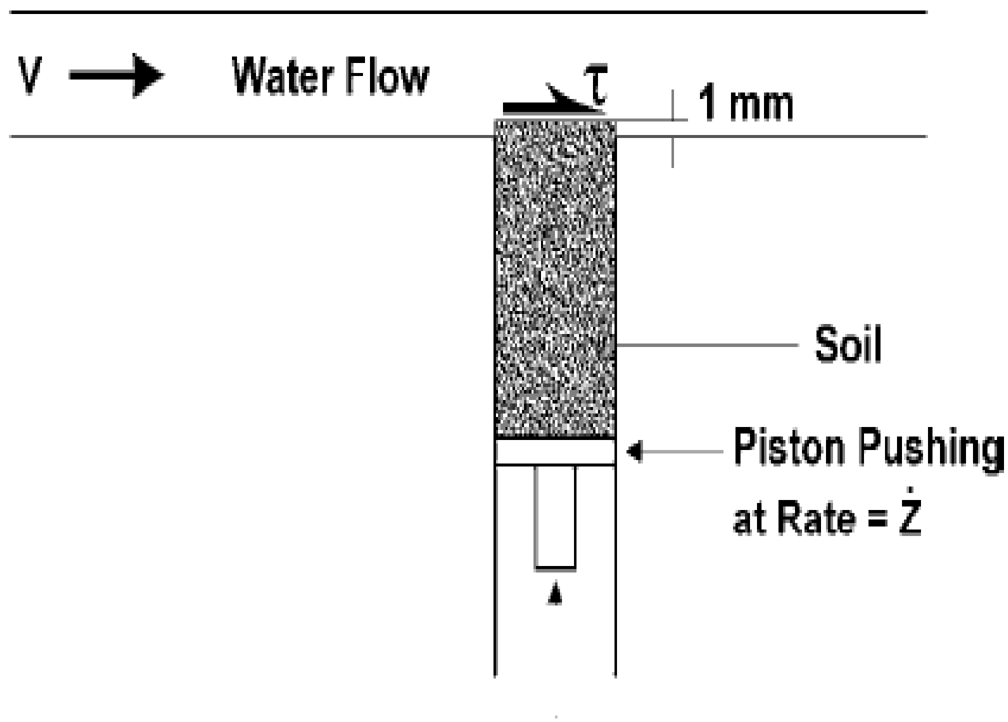
SS Lim(2006)

HET (Hole Erosion Test)



Chi Fai Wan et al (2004)

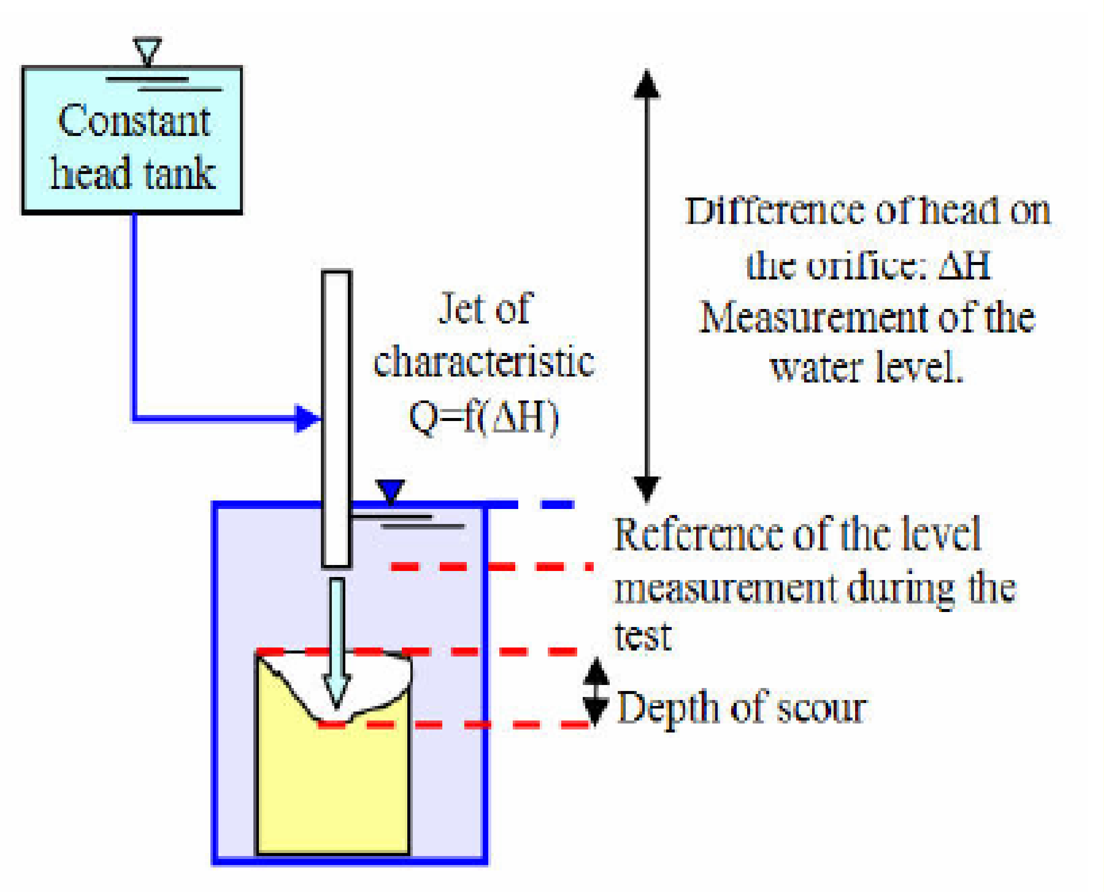
EFA (Erosion Function Apparatus)



Briaud et al
(1999)

Flume Test

Jet Erosion test



G, Hanson et al (2004)