GEOTEXTILE TUBE DESIGN FOR SLURRY WASTE MANAGEMENT: LESSONS LEARNED

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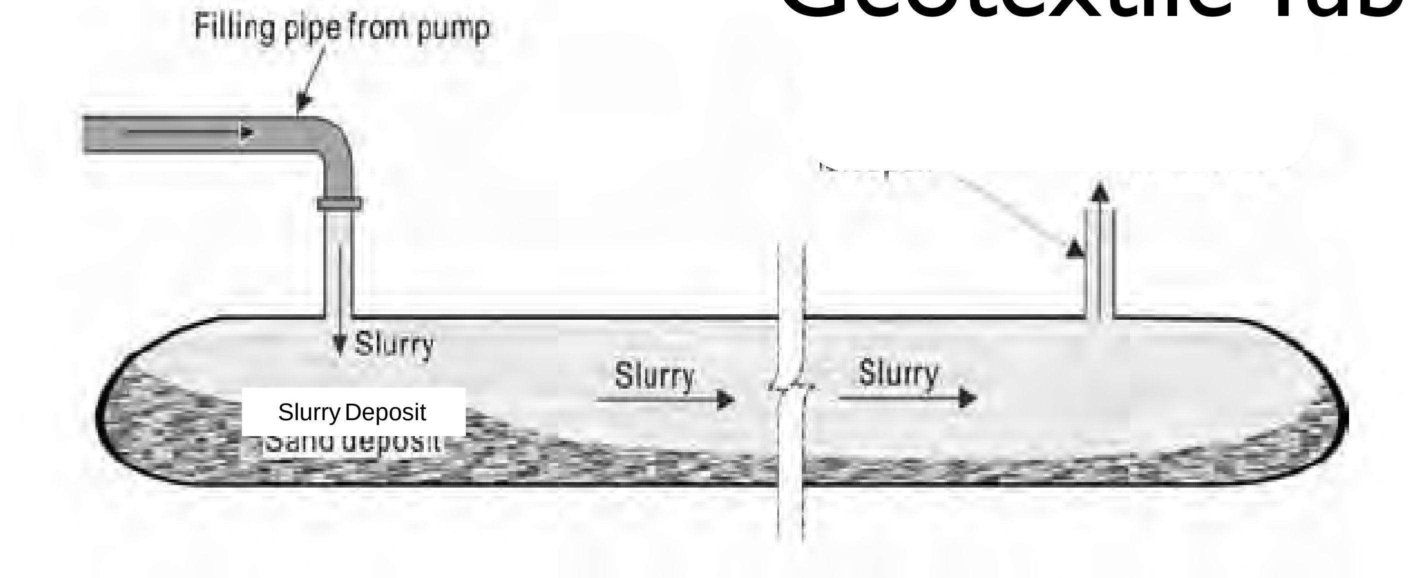
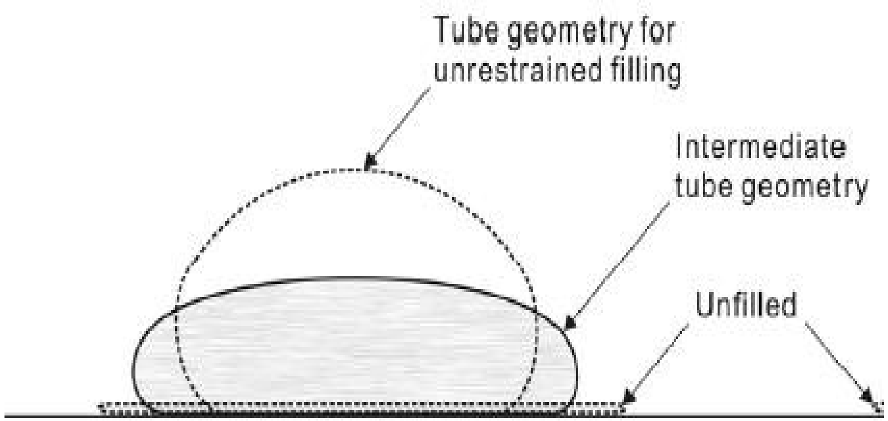
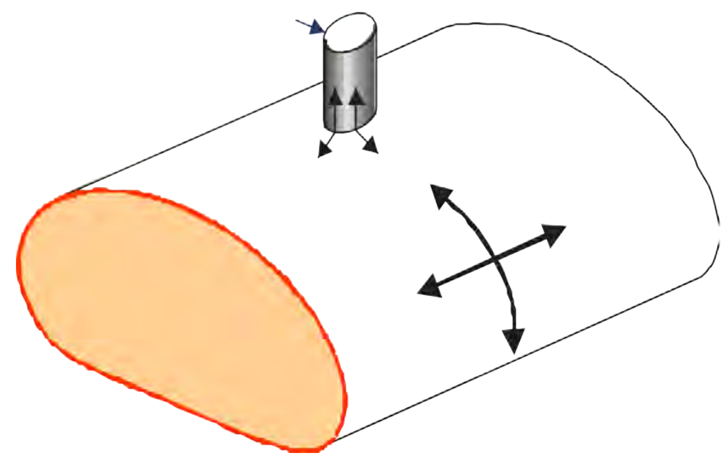
OUTLINE

- What are geotextile tubes?
- How can these be used for managing slurry wastes?
- What are the design and performance requirements?
- Lab and field tests and analytical model
- Case Histories
- Lessons Learned

Geotextile Tubes

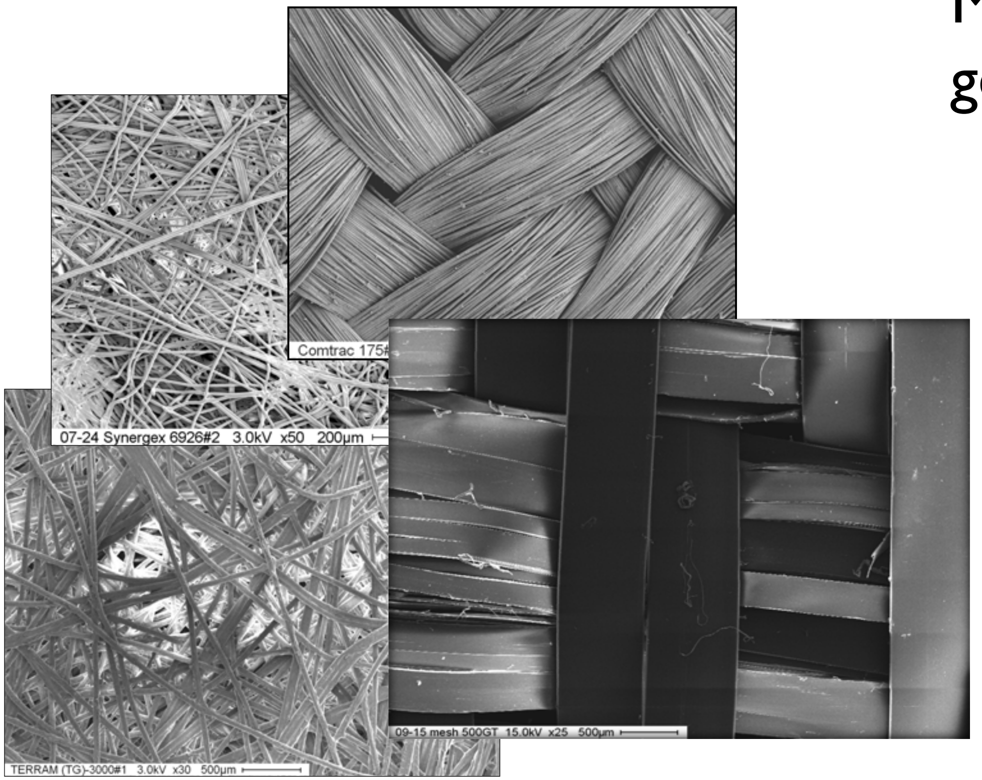






Yee, T.W., Lawson, C. Modeling the Geotextile Tube Dewatering Process. Geosynthetics International, 19, No. 5. pp. 339 – 353.

Geotextiles



High Strength Woven Geotextile

Many dewatering projects used geotextiles of this type.

Geotextile Properties	W1
Polymer Type	PP[1]
Fabric Structure	W[2], MF[3]
AOS[4] (mm)	0.42 (0.27[5])
Permittivity (s^{-1})	0.37
Mass per Unit Area (g/m^2)	585
Thickness (mm)	1.04
Tensile Strength (kN/m)	96x70

[1]PP: polypropylene; [2]W: woven; [3]MF: monofilament; [4]AOS: apparent opening size; [5]According to Khachan et al. 2012

First Application-1996-Fowler-
Municipal Sewage sludge

- Agriculture
- Aquaculture
- Municipal
- Dredging
- Paper Industry
- Food Industry


Excess nutrient removal


Fish processing


Municipal sludge


Sewage treatment


Paper Pulp

Stephens (2005)

INDUSTRIAL SLURRIED WASTE MANAGEMENT

Sedimentation pond	Belt filter press	Centrifuge	Geotextile tubes
			
▪ Consuming large area of land ▪ Unsafe ponds endanger environment	▪ Designed for smaller sludge quantity	▪ High capital and maintenance cost	▪ Optimized space ▪ Alternative use of filled tubes ▪ High sludge quantity

Image reference: https://www.facingsouth.org, http://www.euroby.com, https://abusinessintelligence.com

Geotextile Dewatering Process

Dredging

- Scale of operation
- Economical feasibility
- **Sediments characteristics**
- Soil screening

Pretreatment

- Soil heterogeneity
- Potential contamination
- **Chemical Conditioning**

Dewatering

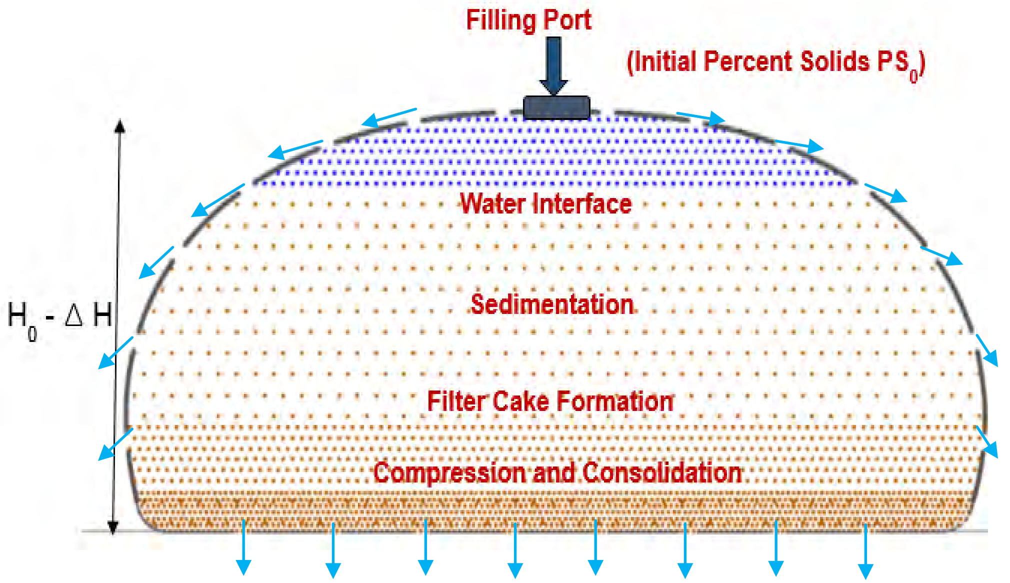
- Geotextile type
- Size and number of tubes
- **Dewatering performance**
- Retained sediments

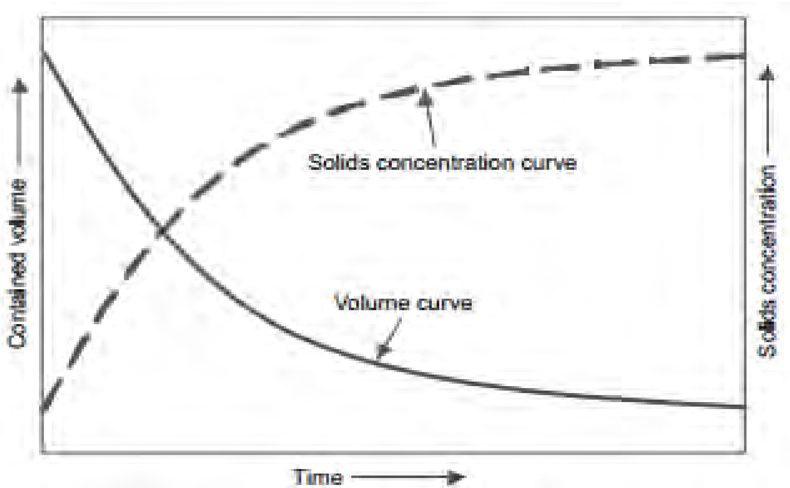
Effluent Treatment

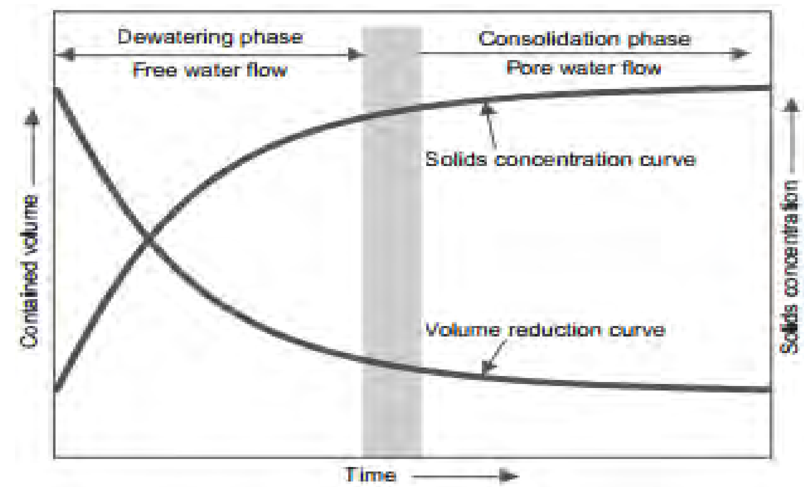
- Residual contaminants
- Effluent smell
- **Residual flocculants**
- Effect on aquatic life

Geotextile Tubes (Physical Processes)

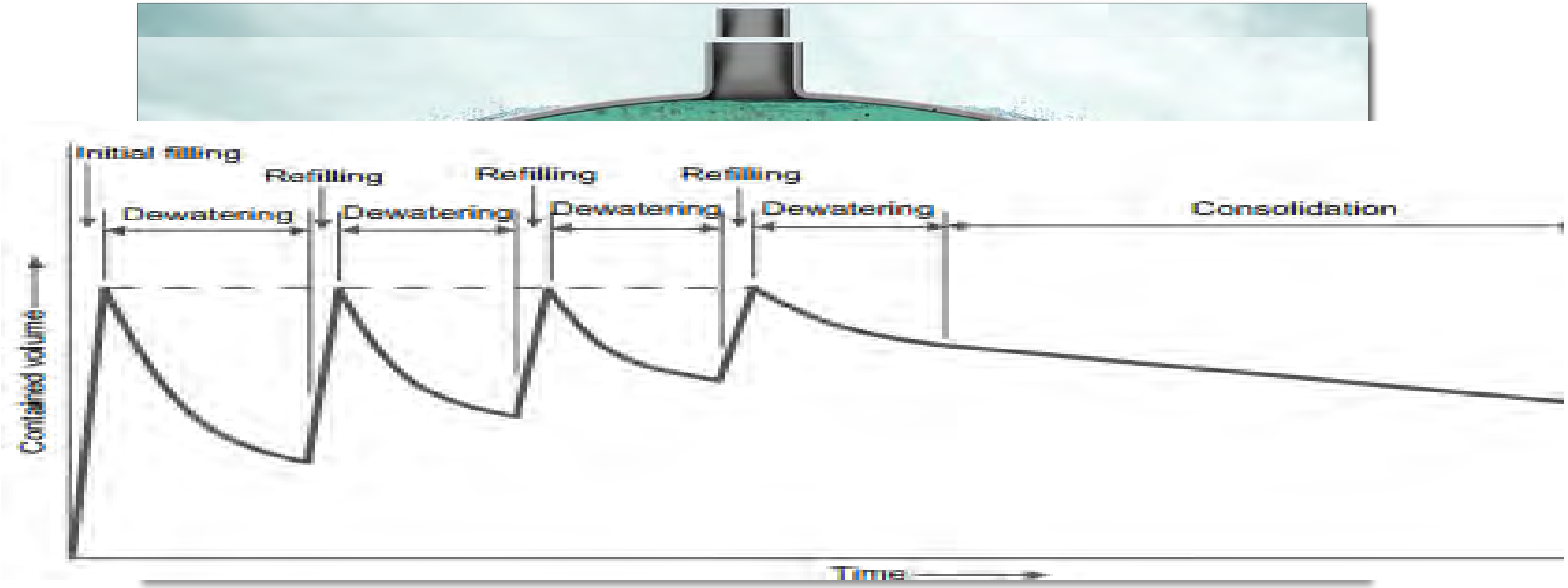
- Filling
- Sedimentation, Filter Cake Formation, Effluent Filtration
- Compression & Consolidation





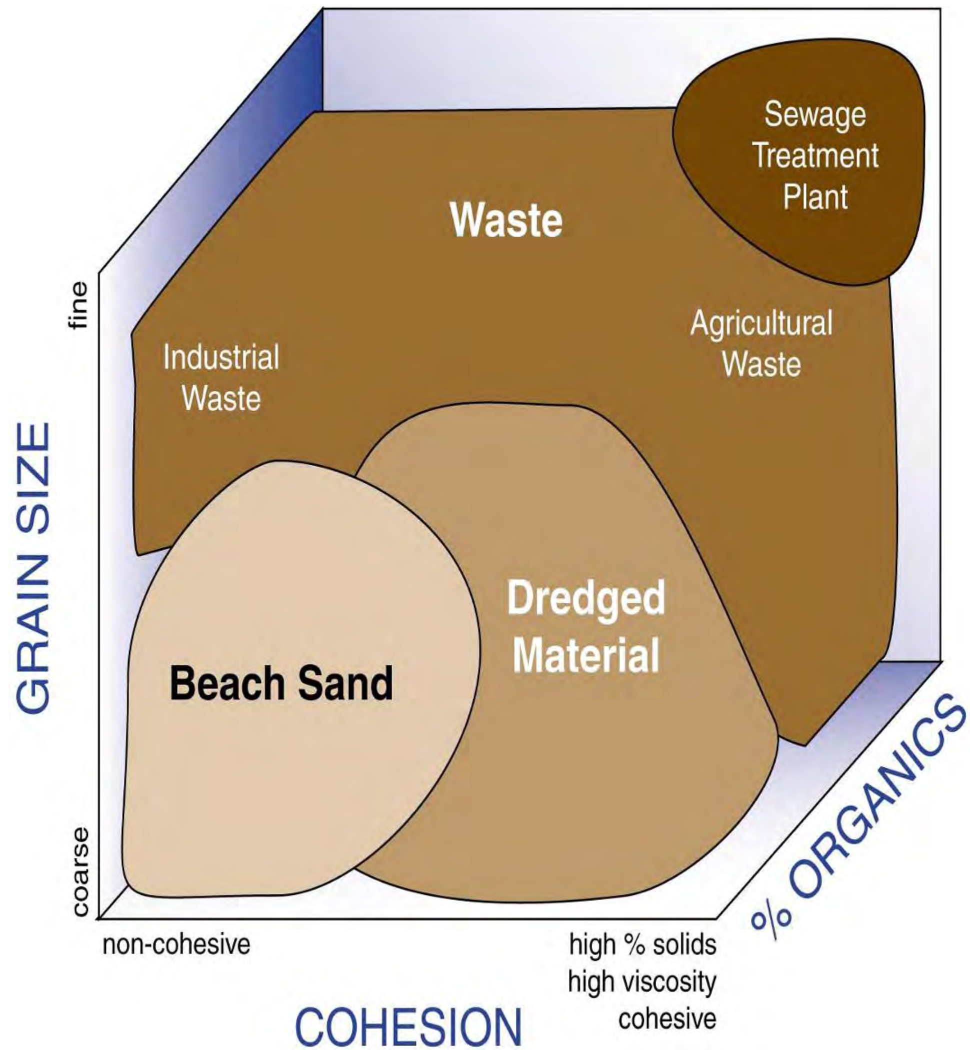


Filling cycle



Why do we need to test?

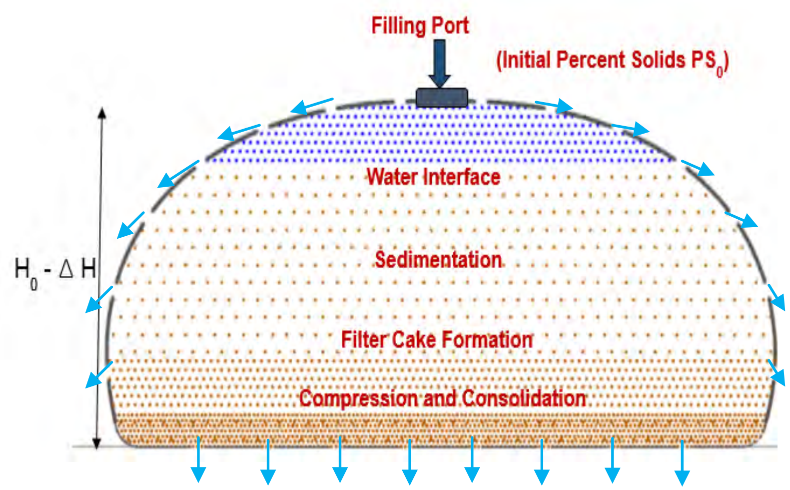
- Each sludge or dredged material has different characteristics that affect how it will dewater in a tube
- Each project has a different measure of success



Gaffney, 2007

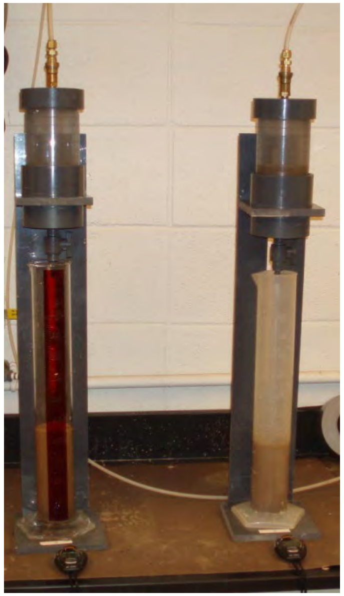
Geotextile Tubes- Performance Evaluation

- Dewatering Rate
- Final Solid Content of the Sediment
- Quality of the Filtrate
    - Turbidity
    - Concentration of contaminants
    - Polymer
- Number of Tubes, Shape and Stacking



PREDICTING PERFORMANCE

Falling Head Test (FHT)
Or
Rapid Dewatering Test

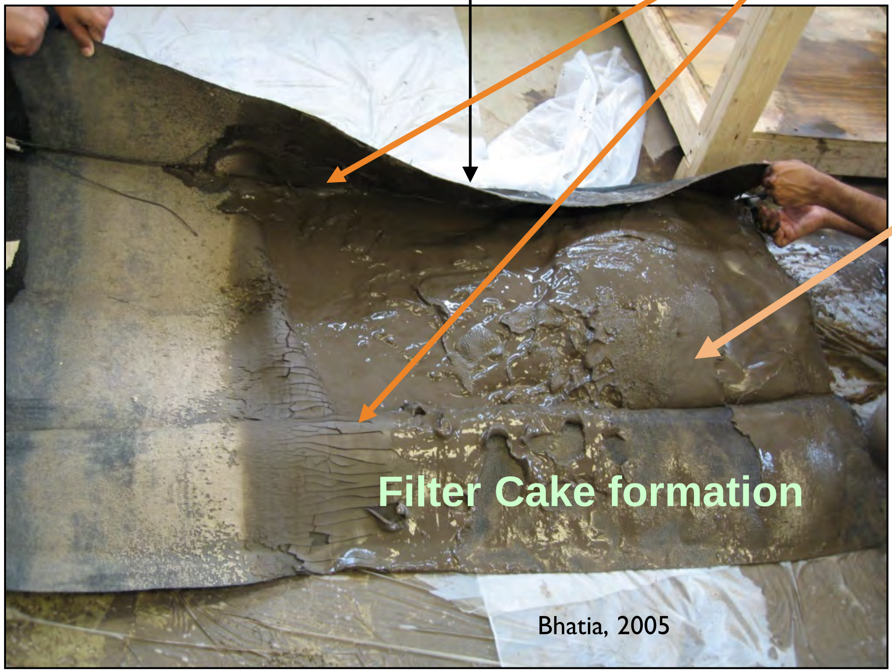


Pressure
Filtration Test
(PFT)

Hanging Bag Test
(HBT)

Geotextile Tube
Demonstration Test
(GDT) (PGDT)

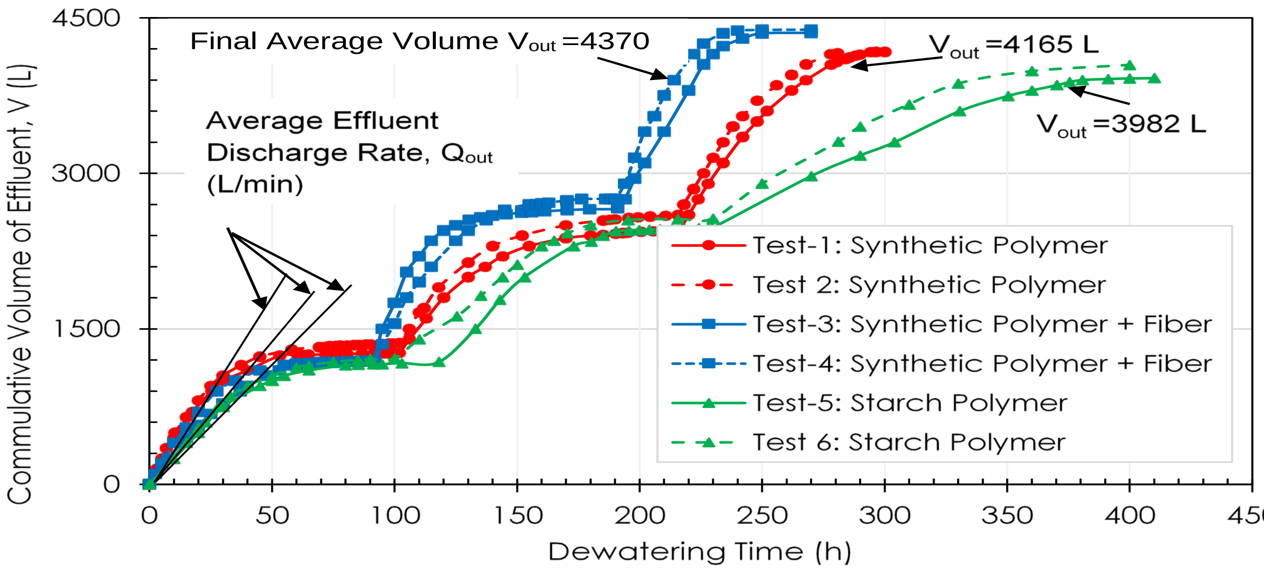
Geotextile Hanging Bag After Test



Retained Sediments

- Initial solids percentage : 33 %
- Final solids percentage: 80 %
- Dewatering Time = 24 hours
- Turbidity of the effluent

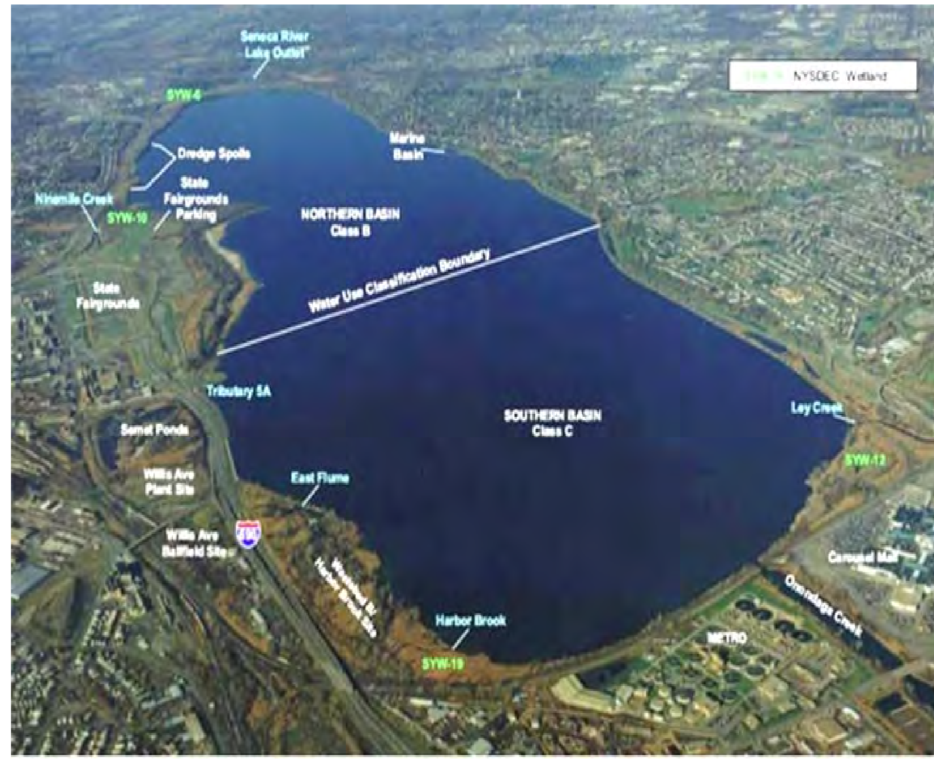
Filtration Efficiency (FE)= 97 %



Final Average Volume V_{out} =4370
V_{out} =4165 L
V_{out} =3982 L
Average Effluent Discharge Rate, Q_{out} (L/min)
Test-1: Synthetic Polymer
Test 2: Synthetic Polymer
Test-3: Synthetic Polymer + Fiber
Test-4: Synthetic Polymer + Fiber
Test-5: Starch Polymer
Test 6: Starch Polymer
Commulative Volume of Effluent, V (L)
Dewatering Time (h)
0
1500
3000
4500
0
50
100
150
200
250
300
350
400
450

CHALLENGE: CLEANING LAKES, RIVERS, PONDS..

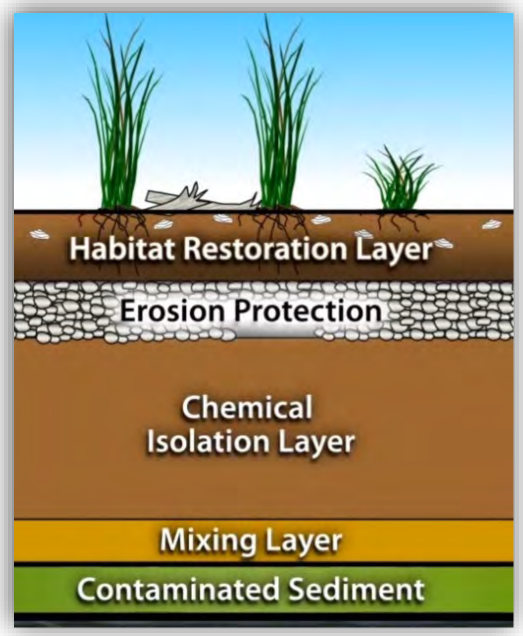
- Approximately 400 million cubic yards of sediments are dredged every year within the US, for navigation (Meegoda, 1997)



Tully mudboils

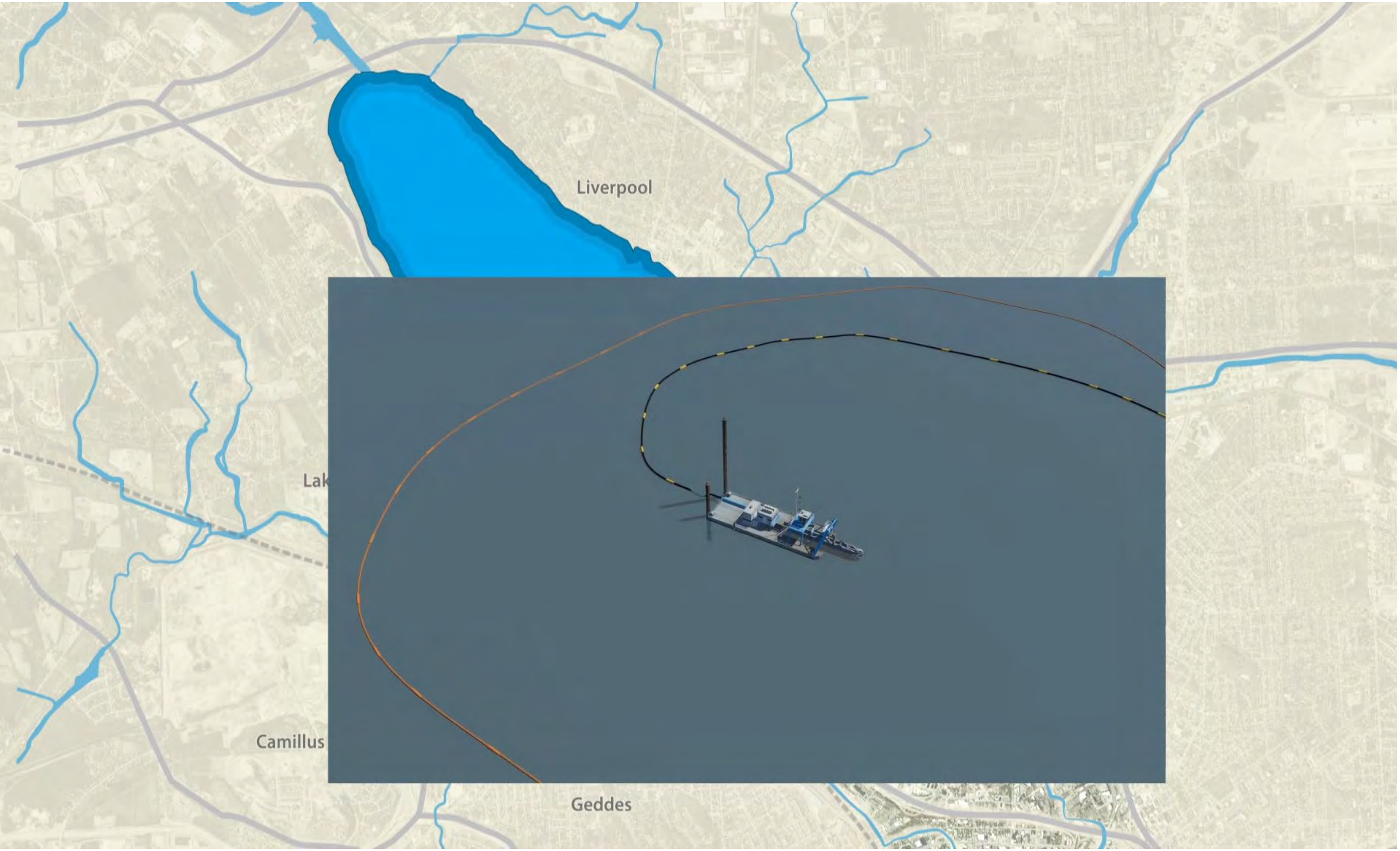
Restoration of Onondaga Lake

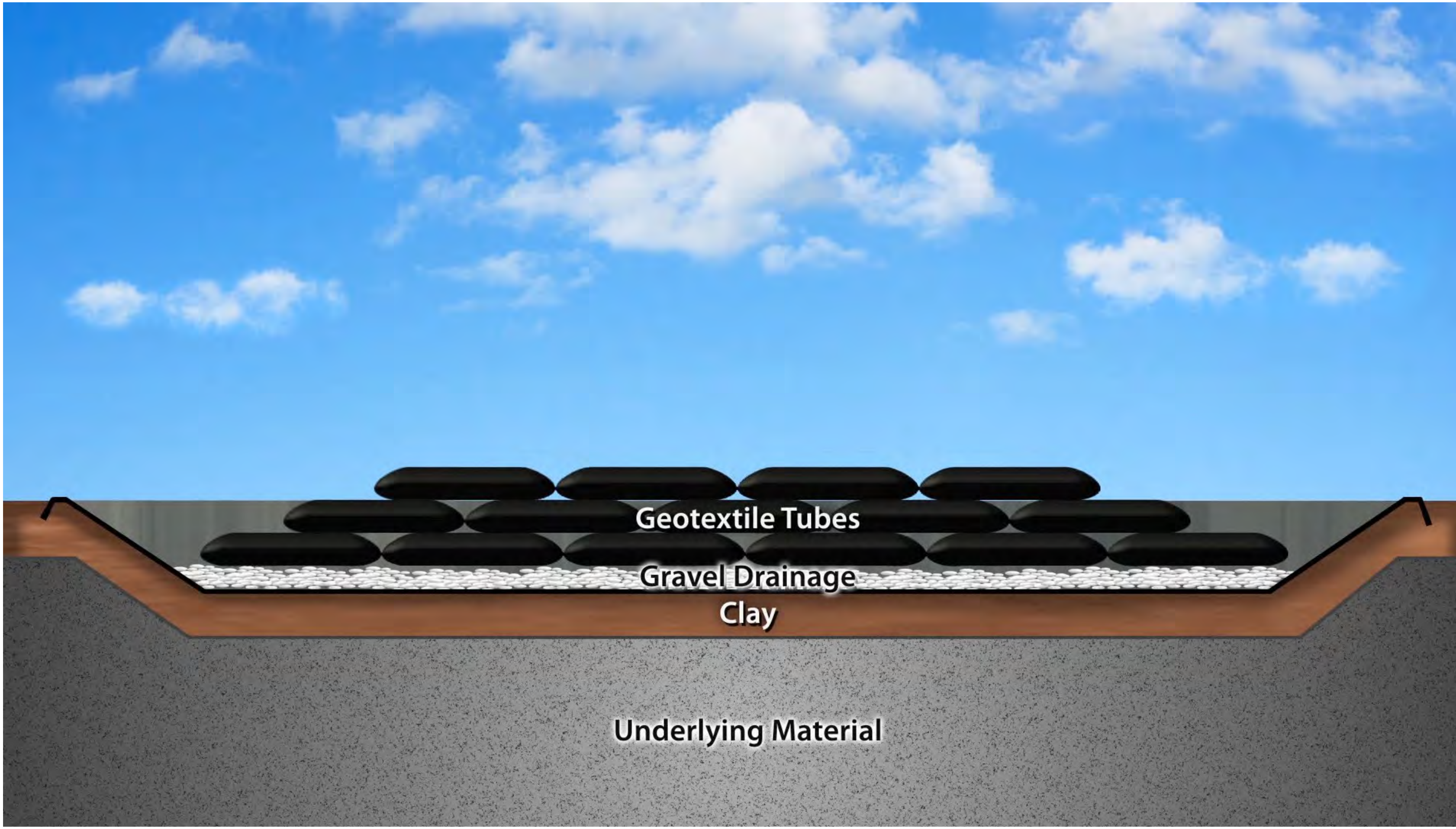
IN-LAKE REMEDIATION AREAS



Isolation cap 172 ha

Thin layer cap 11ha


Liverpool
Camillus
Geddes

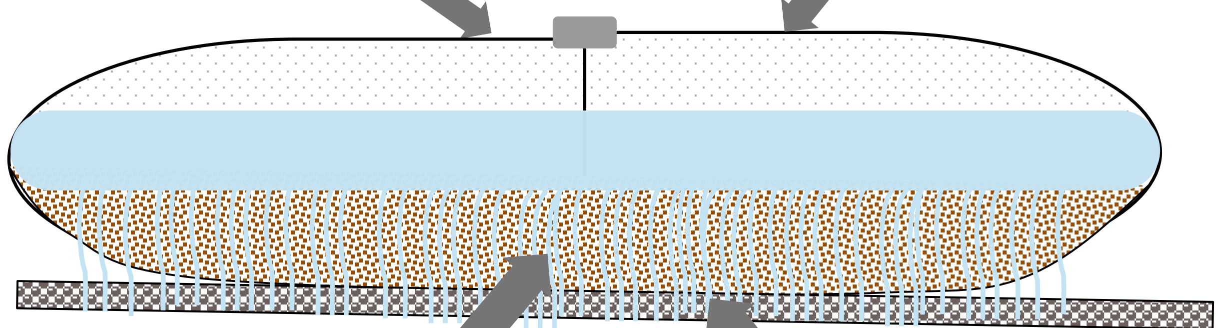

Geotextile Tubes
Gravel Drainage
Clay
Underlying Material

New Flocculants

Synthetic, Natural

Predicting Field Performance

Large Scale tests, FEM Modeling



Centrifuge and 2 D Tests

Filter Cake Properties (Solid content, Strength, compressibility)

China Clay , Streaming Current and Toxicity Tests

Effluent polymer residual concentration and Toxicity

Case History #2

Scudder's Pond

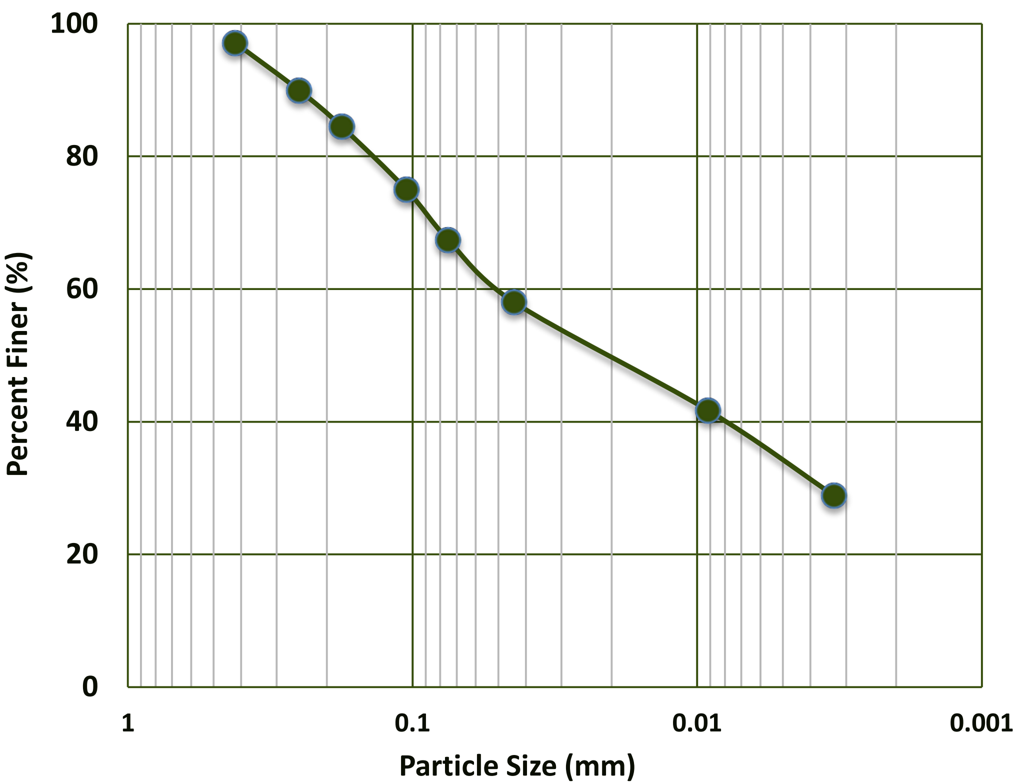
Geotubes set up at the site

Geotextile tubes were selected –cost effective

DESIGN

- 5000cubic yards of sediment
- 5 tubes-
  - 2(45ft circumference,86ft long)
  - 2(75 ft circumference, 100 ft long)
  - 1(45ft circumference,129ft long)
- Jar Test :10ppm cationic coagulant, 5ppm anionic flocculant
- GDT Test- to estimate % solid

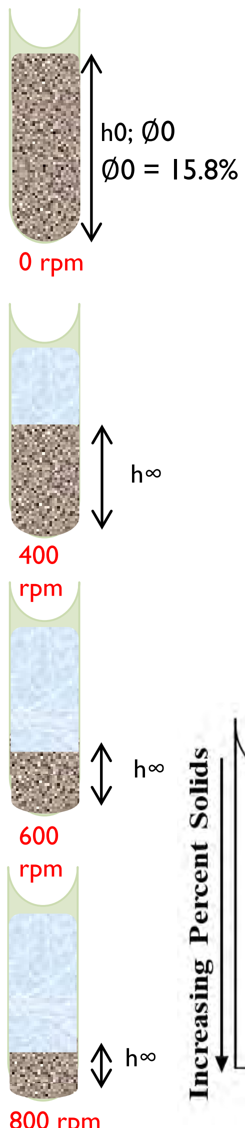
Material

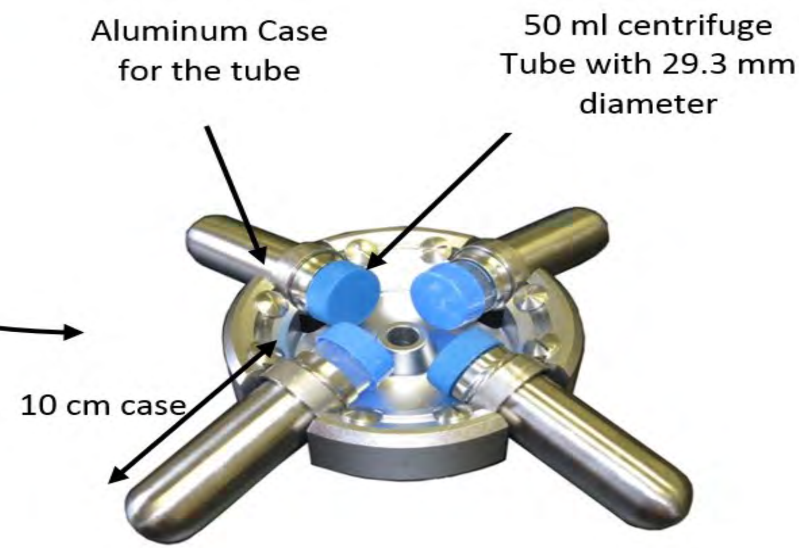


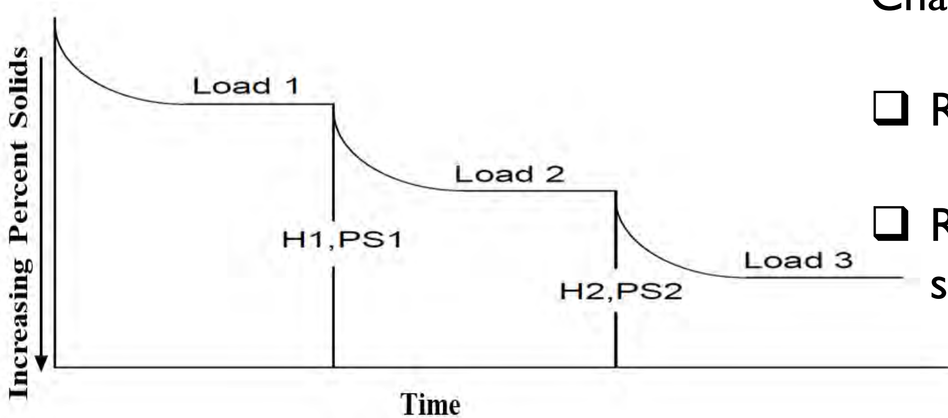
Particle Size Distribution of the Sediments

Property	Measured Value
Specific Gravity (ASTM D854 – 10)	2.37
pH (pH Tester 20)	6.5-7
Charge Density (meq/g) (PCD Mutek-2)	0.005
Burned fraction of the fines (at 250^0 C)	6%

CENTRIFUGE TEST

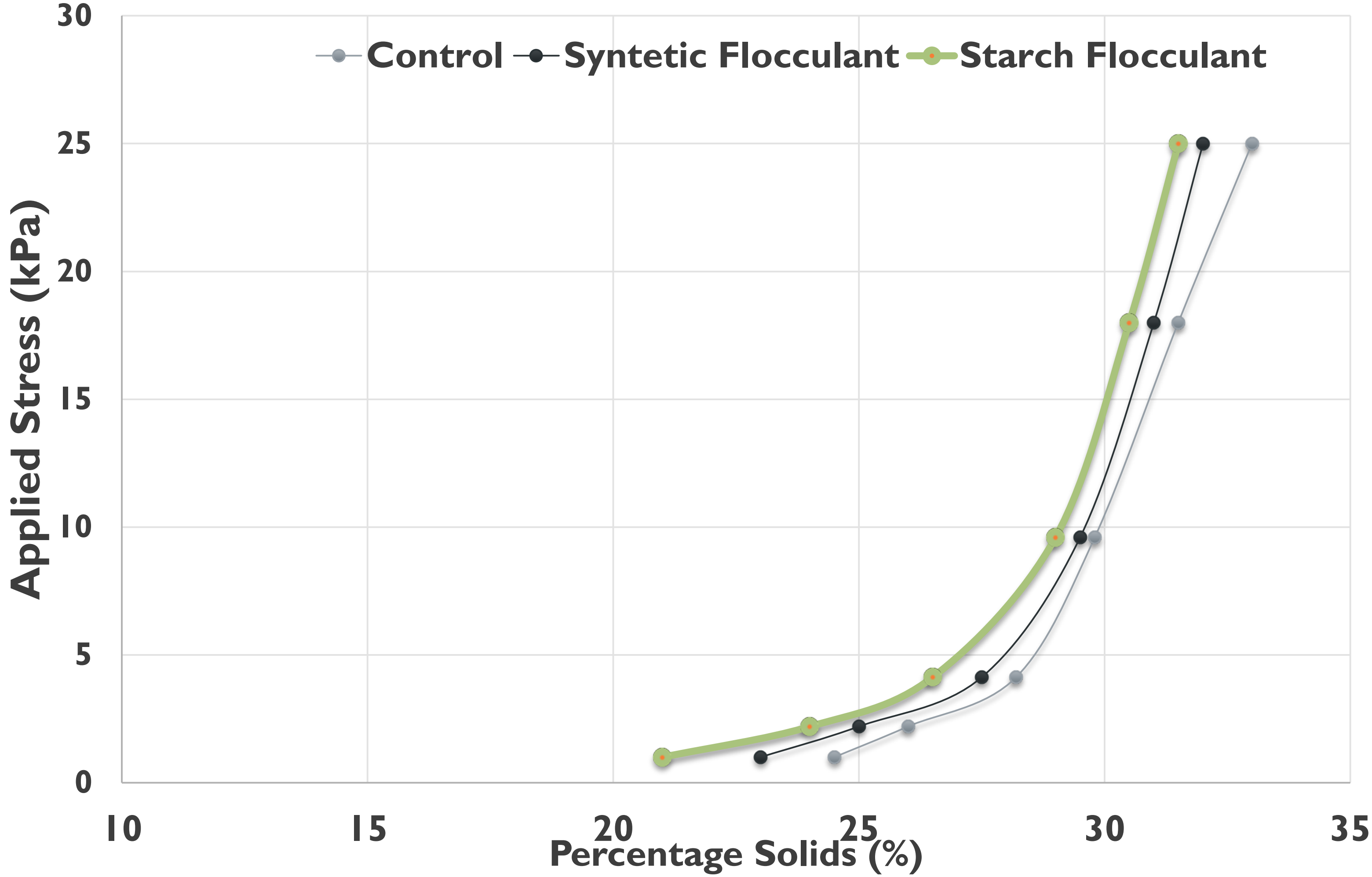






Change in:

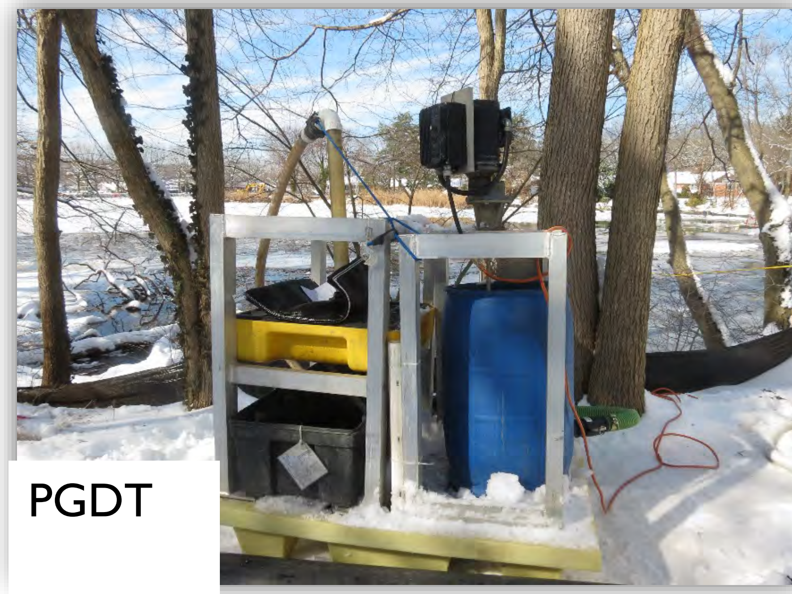
- ❑ Retained Sediments Volume
- ❑ Retained Sediments Filter percent solids



Control
Syntetic Flocculant
Starch Flocculant
Applied Stress (kPa)
Percentage Solids (%)
0
5
10
15
20
25
30
10
15
20
25
30
35

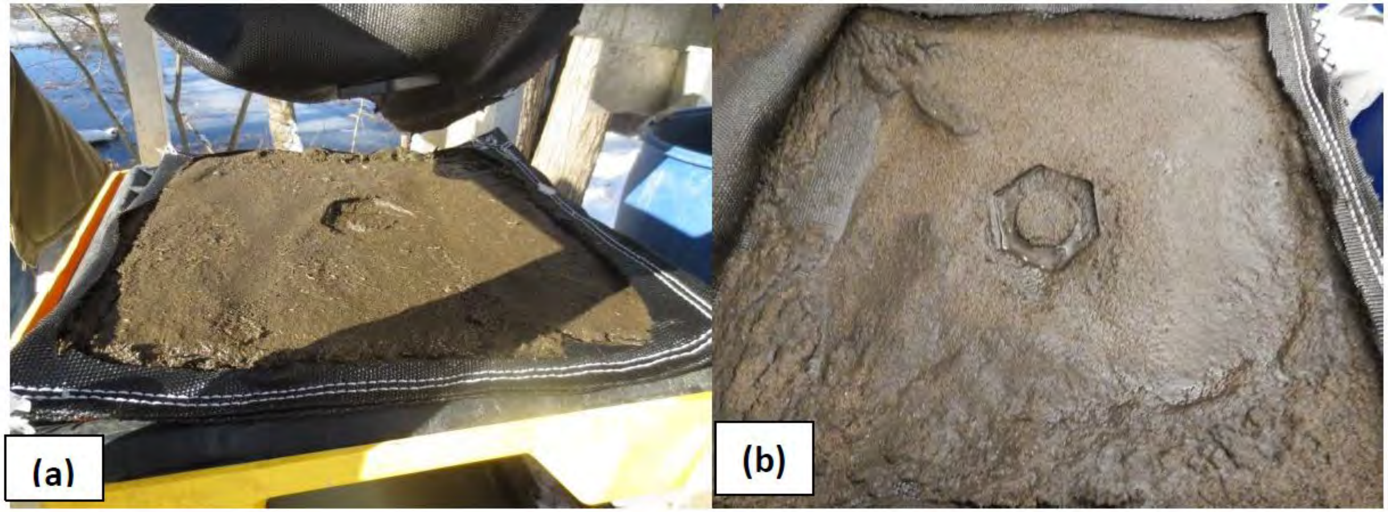
GDT AND PGDT TESTS IN FIELD

GDT Test

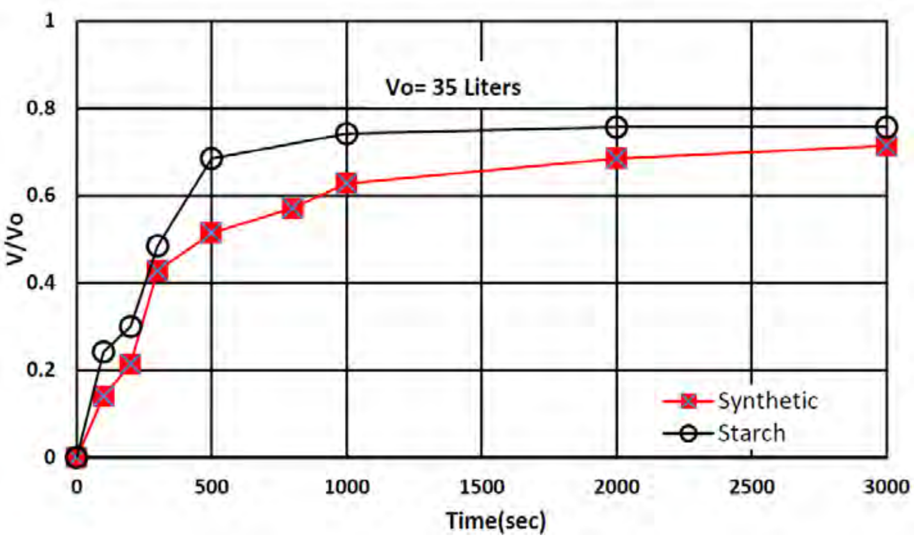


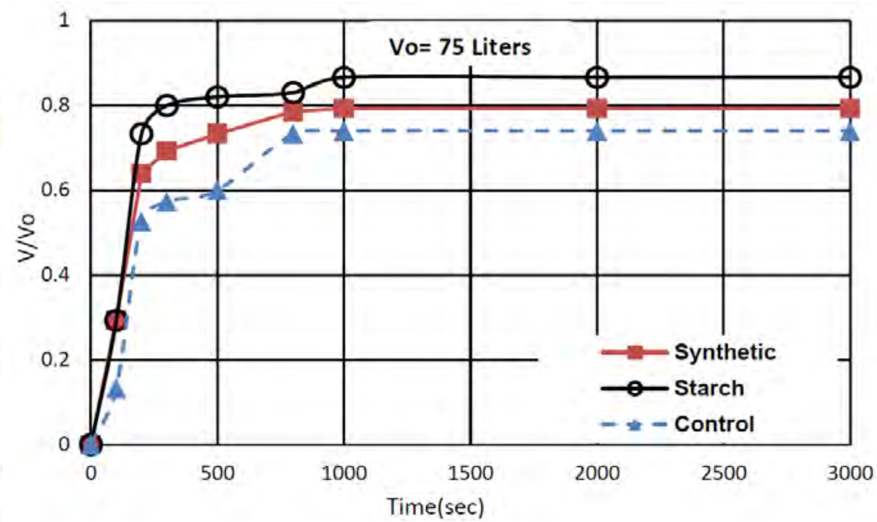
PGDT

Test	Polymer	Percent Solid (%)
GDT	Starch	13.9
	Synthetic	14.1
PGDT	Starch	13.3 (at center) , 14.0 (at Corner)



a) PDGT test at pond site   b) GDT control test in the lab





RESULTS

Test	Flocculants	% Solid	% Solid
		Field	Laboratory
GDT	Synthetic	14.1 (fine)	36.6 (coarse)
	Starch	13.9 (fine)	40.3 (coarse)
PGDT	Starch	13.7 (fine)	NA
Centrifuge	Synthetic	21-23 (fine), 44-46(coarse)	Ave:33.5%
	Starch	23-24 (fine), 42-44(coarse)	Ave:33.25%
Full Tube	Synthetic	21-34%	

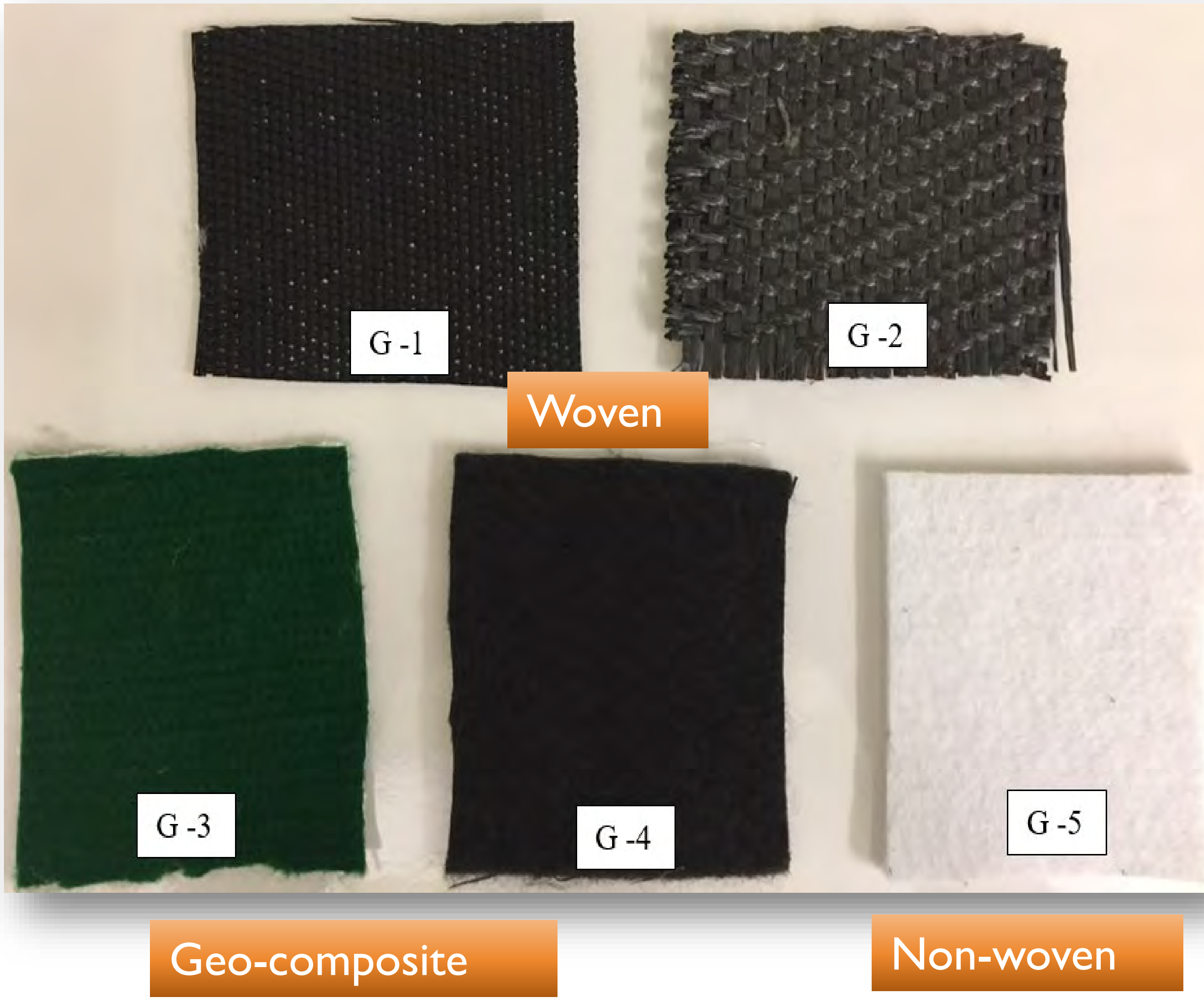
Case History # 3

www.tradeusa.com

- Industrial Settling Pond filled with glue-slurry
- Core samples were collected
- Low Sp. Gravity (1.36)

- Tests:
  - Lab- PFT,P2DT,Centrifuge,
  - Field: GDT

MATERIALS

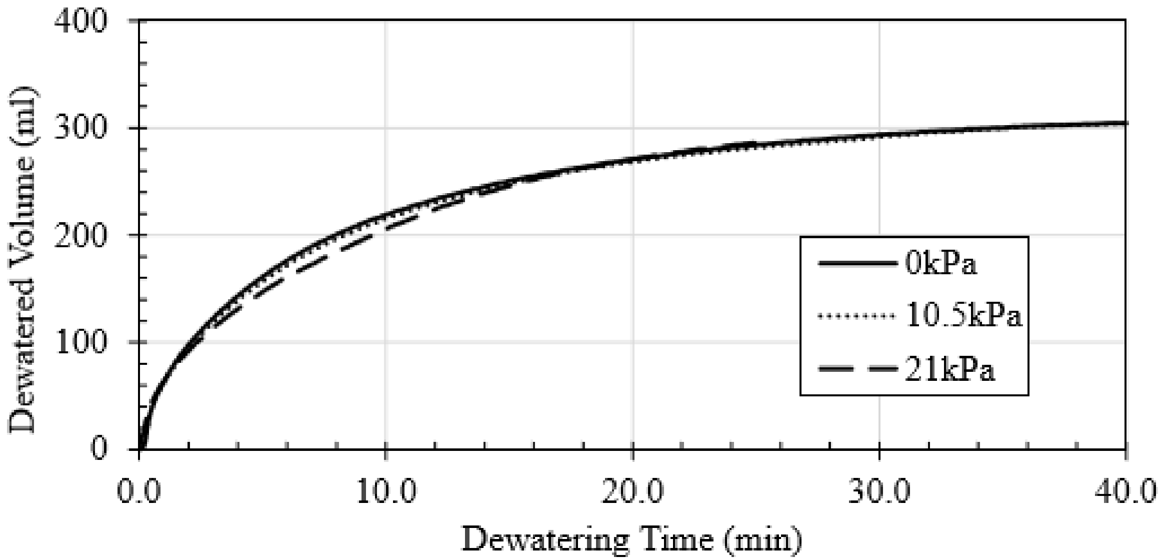

G -1
G -2
Woven
G -3
G -4
G -5
Geo-composite
Non-woven


mL 0
±5%
500 mL
±5%
600 mL
PYREX®
100
400
200
300
300
200
No. 1000
Tully Slurry


Glue Slurry

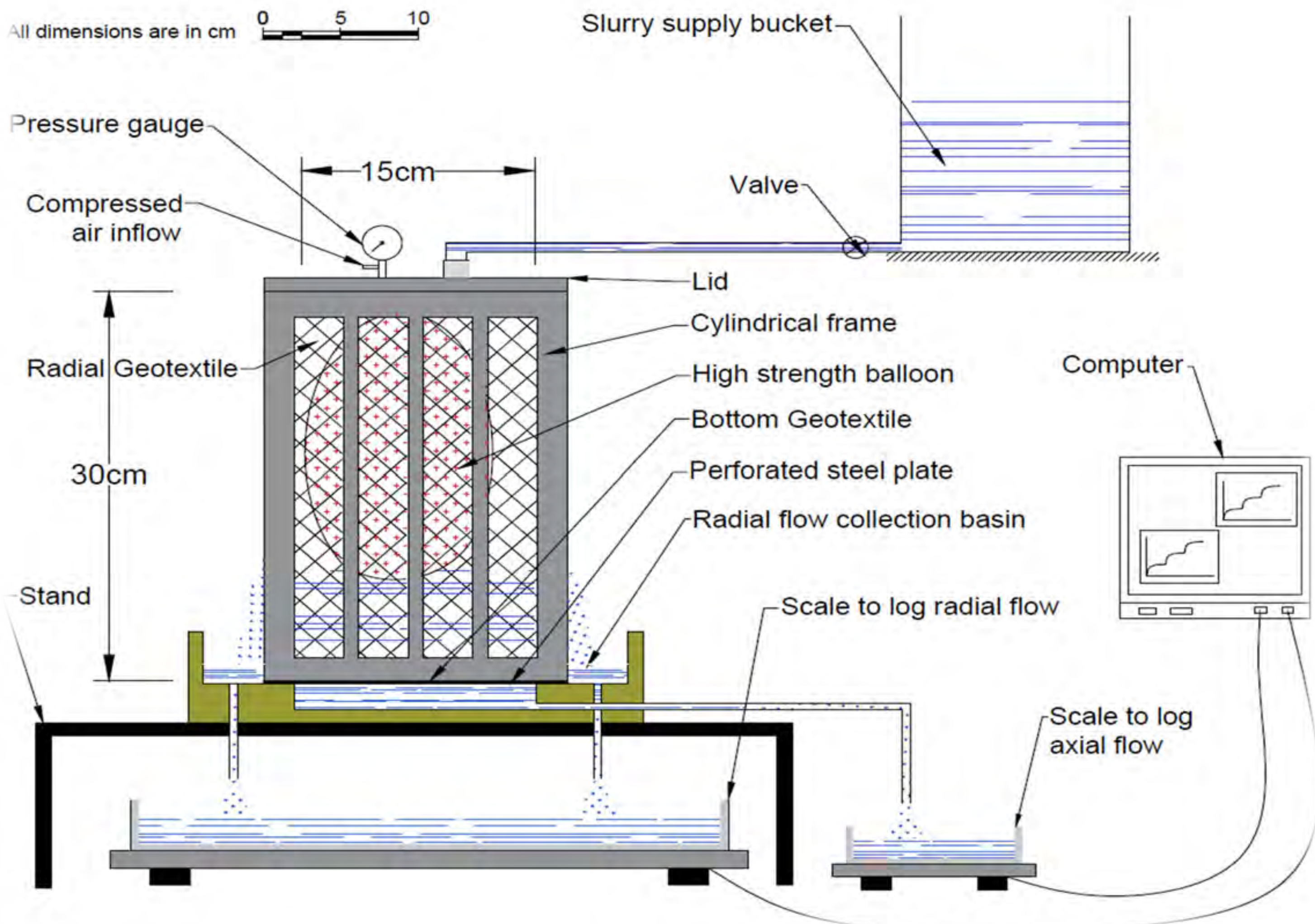
Before and After Drying

PFT Test Results

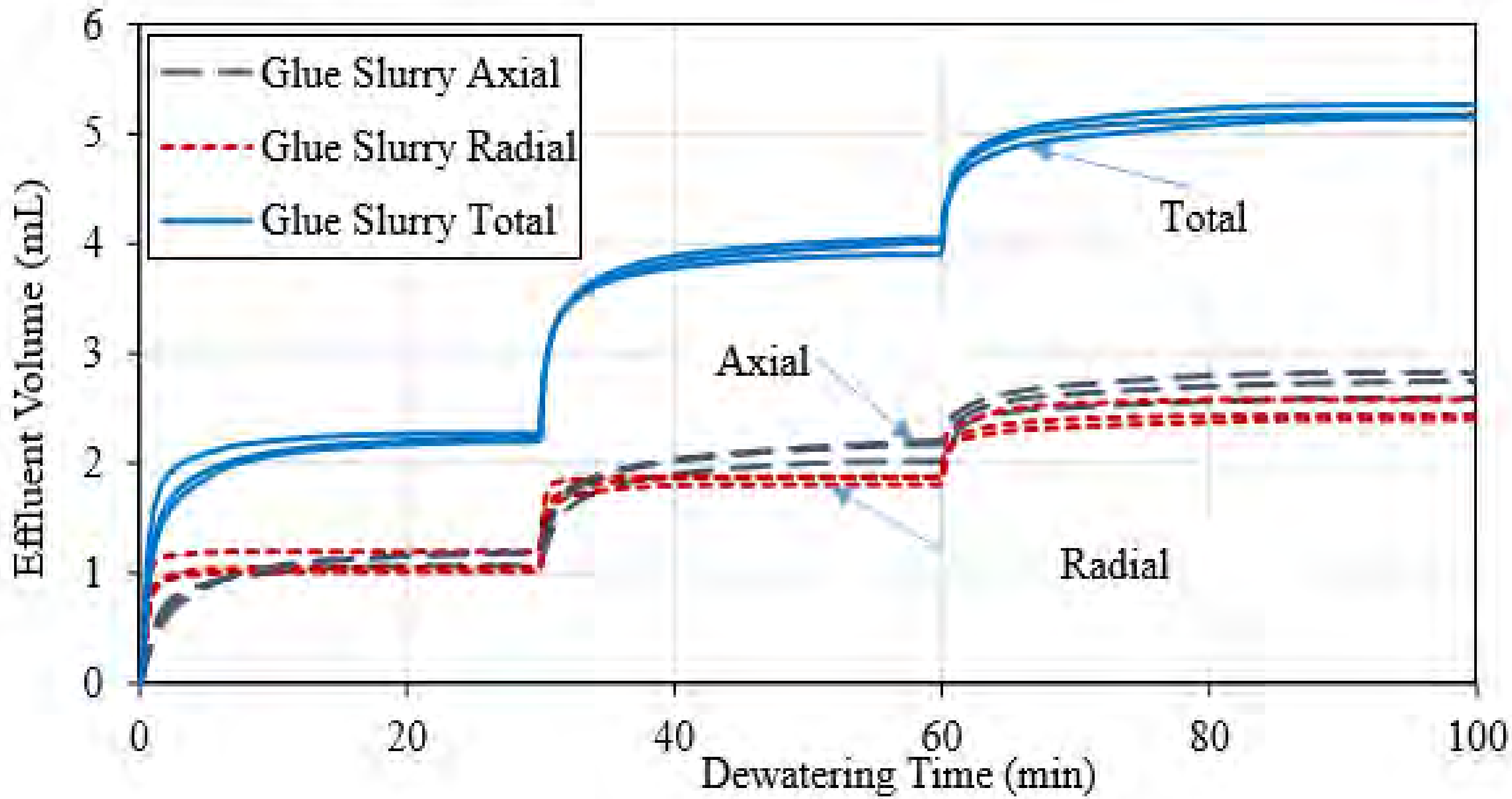


Pressure Filtration Test(PFT) Under Different Pressure

2-D DEWATERING TEST (P2DT)

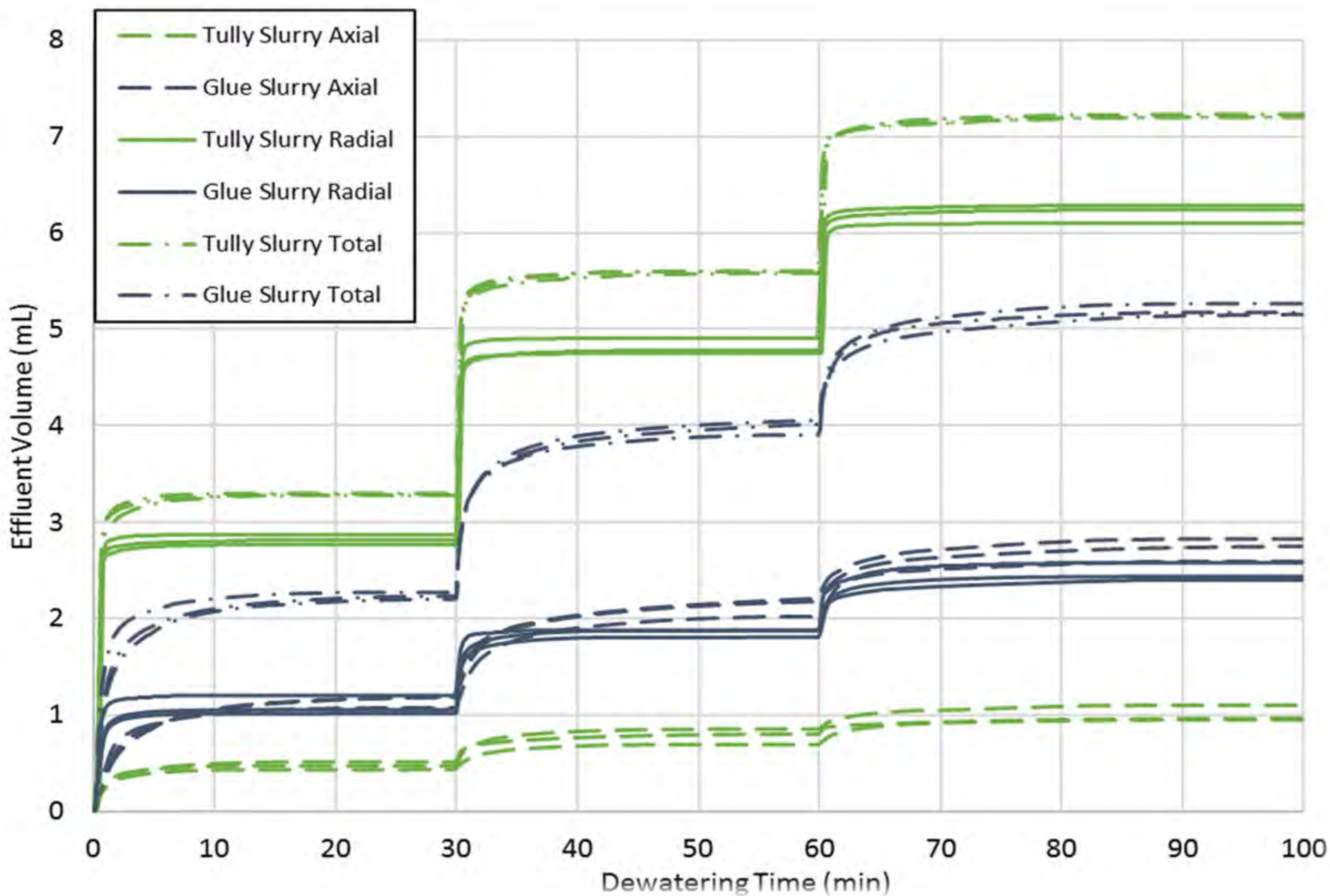


P2DT Test Results



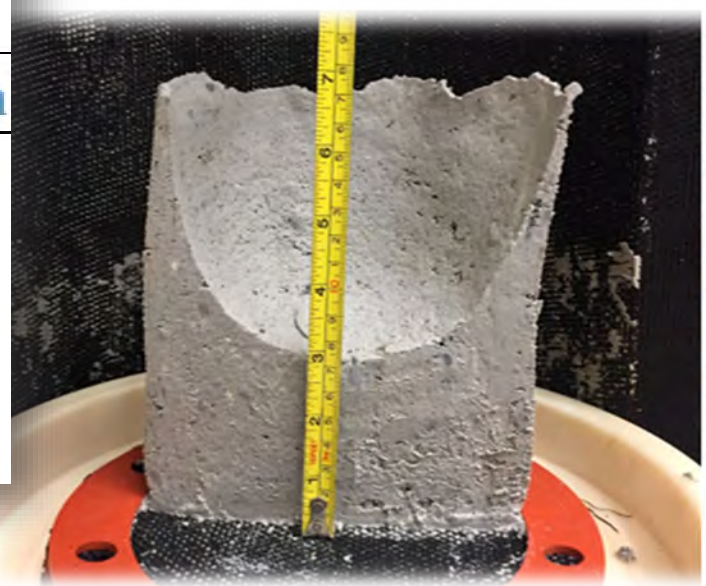
Effluent Volume VS Dewatering Time for Glue Slurry

ROLE OF SLURRY



FILTER CAKE

- Glue Slurry with 6.3% initial solids concentration
- Final solids concentration was about 20%



MODEL

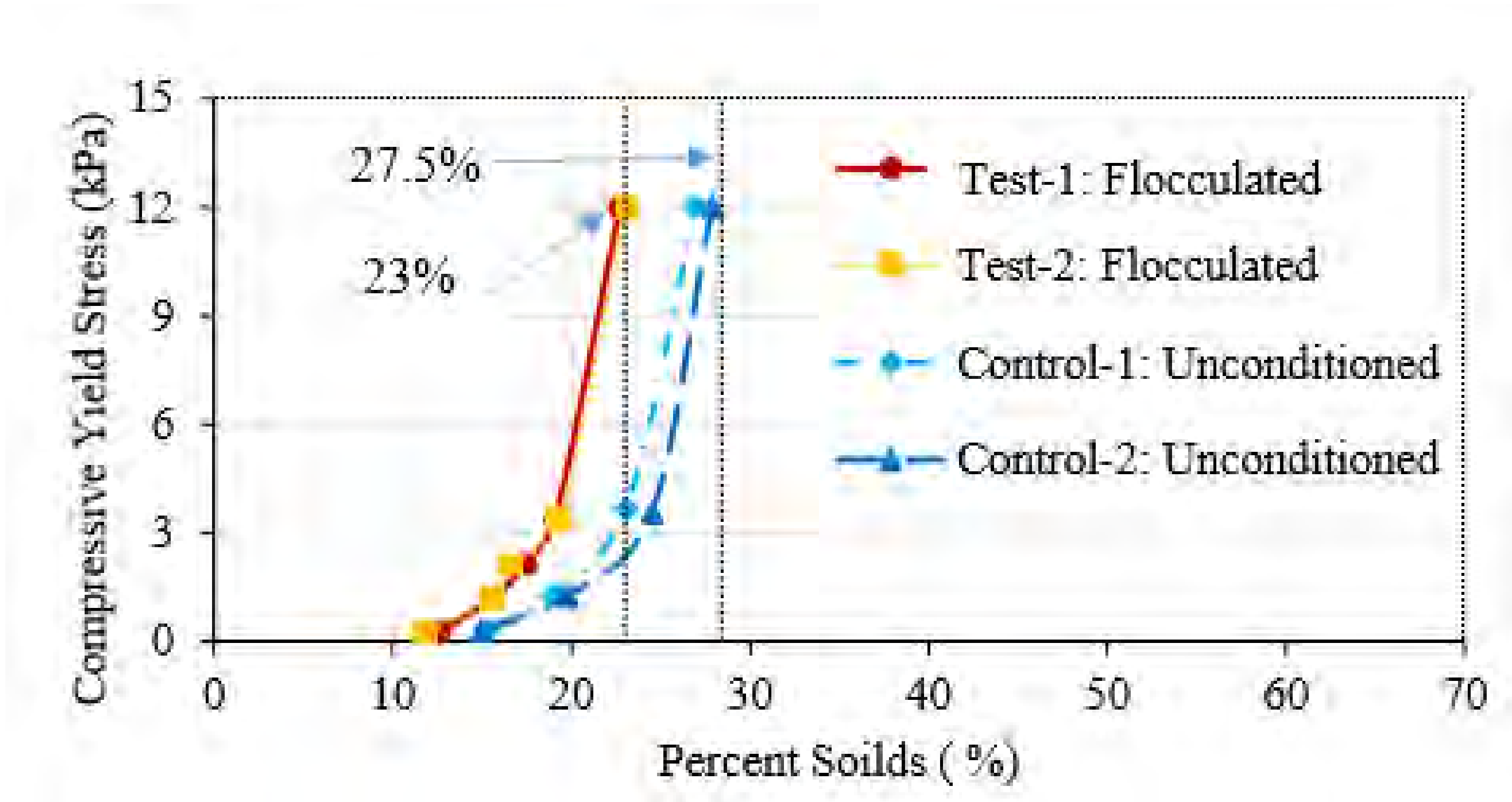
- Filling Phase
  - Floc Quality Factor (A_p)

$$Q_{out.f} = A_p \cdot n_{in} \cdot Q_{in}$$

- Drawdown Phase
  - Empirical Power Factor (q)

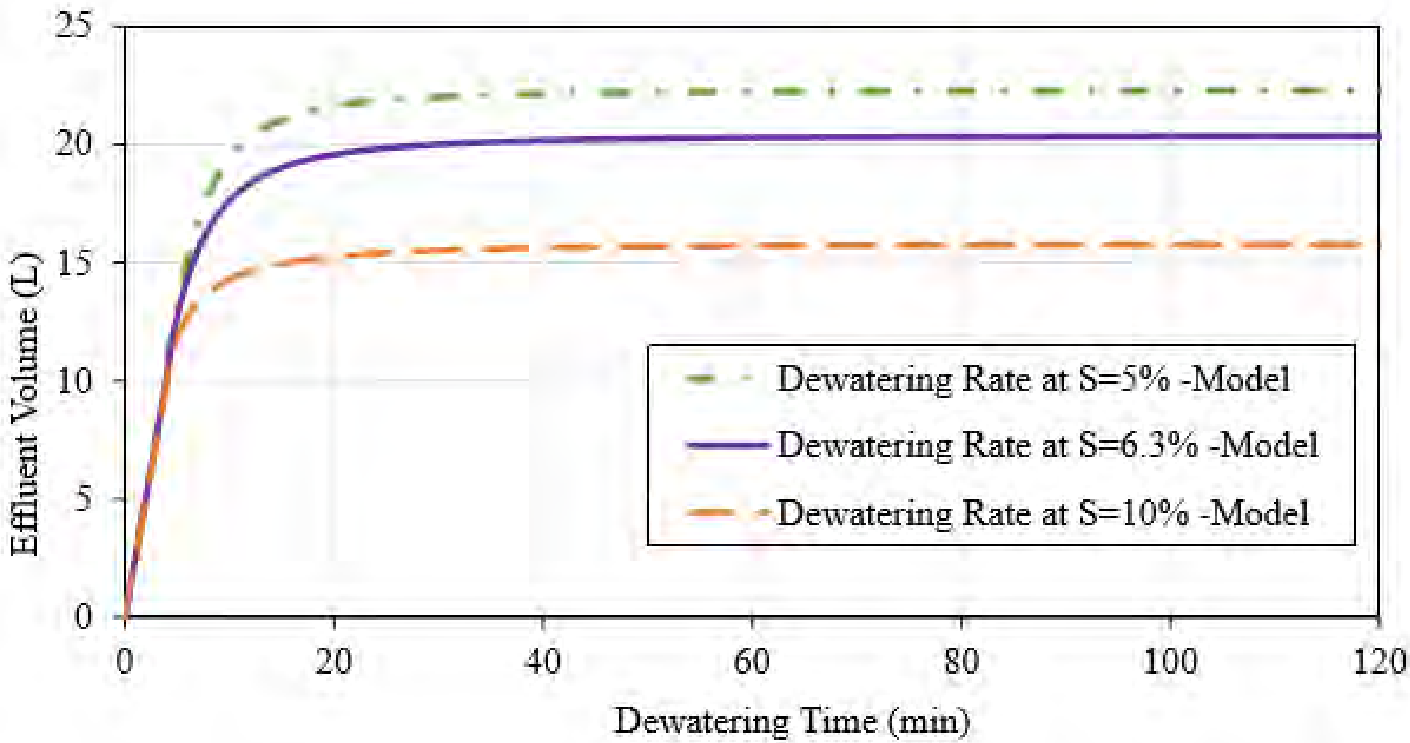
$$V_{T(i)} = V_{T(i-1)} - A \cdot \left(n_{(i-1)}\right)^q \cdot \Delta t$$

Centrifuge Test Results



Solid Concentrations of Flocculated and Unconditioned (Control) Slurry

Parameter	Experimental		Analytical Model
Final Solid Concentration, S(%)	Range	Average	23.1
	19.0-22.8	21.2	



Dewatering Rate of GDT Model at Different Initial Solid Concentrations

Comparison of Final Solid Concentration

Field/ Lab/ Model	Tests	Solid Concentration (%)	
		Range	Average
Field	GDT	19.0-22.8	21.2
Lab	P2DT	19.4-23.6	21.9
	PFT	17.0-19.4	18.7
	Centrifuge	22.6-24.3	23.0
Model			23.1

LESSONS LEARNED

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- Geotextile Tubes is a viable technology for the slurry waste management.
- Available lab tests (Centrifuge and P2DT) and model can help designers.
- Research/ Innovation in collaboration with industry can lead to better solutions, and newer applications.