Evaluation of Belted Strand Retention Fabric and Conventional Type C Silt Fence using ASTM standards

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Introduction

- Users of erosion and sediment control (ESC) products have difficulty of comparing the performance of different products and techniques.
- Few methods available for evaluating different products for approval by State agencies.
- Different test procedures make it hard to compare results

Literature review

- Some standard tests available
  - WisDOT (Several Categories)
  - ECTC and North American Stormwater and Erosion Control Association are working on providing test procedures and standards. Labs approved for testing of erosion mats:
    - Colorado State University
    - San Diego State University
    - E-Lab, American Exclesior Inc.
    - Texas Transportation Institute's Hydraulics, Sedimentation, and Erosion Control Laboratory
- Not Many Procedures for testing Silt Fence

- Wyant(1980) conducted a comprehensive study on silt fence, which led to development of ASTM D5141 (Filtering Efficiency and flow through)
- Both Kouwen(1990) and Barrett et al. (1995) studied silt fence using different procedures, both concluded that deposition from the large ponded volume created by the fence was the main mechanism for sediment removal.
- Thiesen(1992) suggested that the Apparent Opening Size of the fabric determines the amount of storage capacity of the fence.

- Thomas Carpenter and Joel Sprague created new procedures for testing the effectiveness of sediment retention device. Primarily looking at installation practices.
- Most State agencies look at material properties including strength of fabric, opening size, and flow rate.

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What is BSRF?

- Woven geotextile.
- Biodegradable
- Innovative design

Objective

- To test the filtering efficiency and flow rate of Belted Strand Retention Fencing (SiltSaver) and Type C silt fence using ASTM standard D5141
- To evaluate the effectiveness of this new fence material.
- Not approved in Georgia due to low flow rate and not meeting strength specifications.

Procedure 1

- Flume constructed according to ASTM standard. (85x125 cm)
- Flume set at a 8% slope
- 50 L of mixture added to top.
- Collect all effluent.

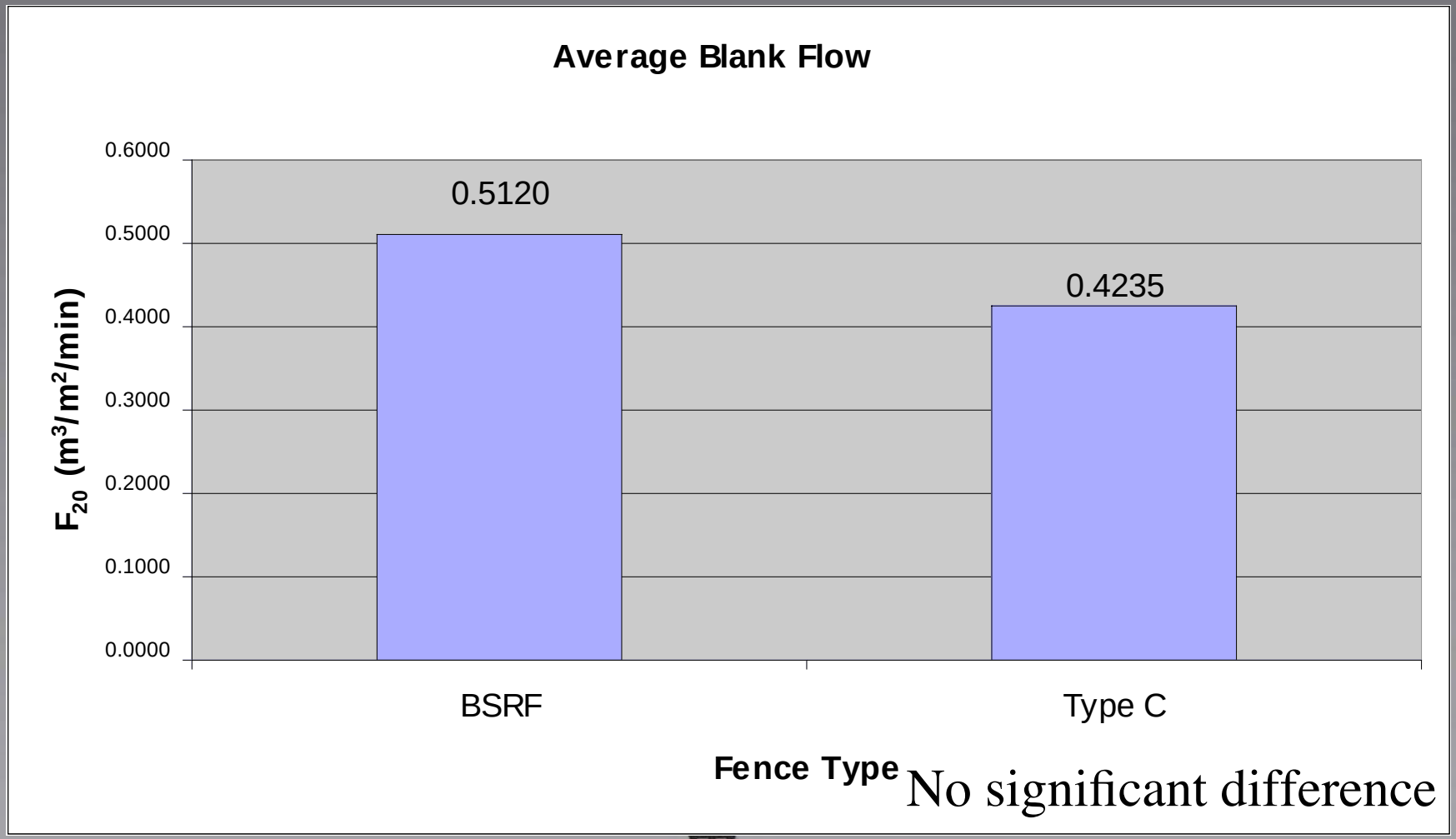
Procedure

- The first run sediment free water
- Second run was a 2890 ppm (standard) concentration of sediment laden water.
- A 3rd run with a 5780 ppm (Double) concentration was run on the same fence.
- Total time of flow was recorded to 20 minutes.
- Subsamples of the sediment laden water and the filtrate were taken for analysis.
- Procedure was replicated three times for each fence.
- Three different soils, Sand, Clay, Silt Loam

Results: Flow Rate

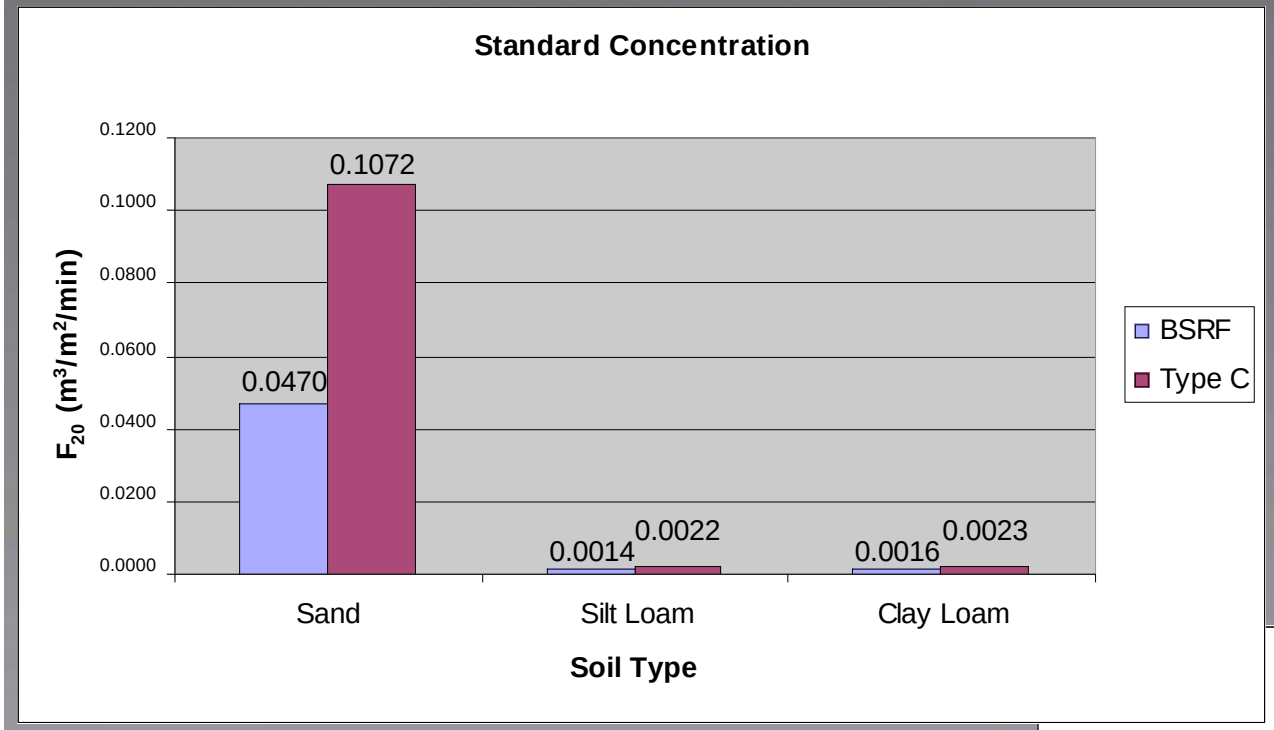
- Equations in Standard report flow rate in $m^3/m^2/min$.
- Errors in equations which are being corrected by ASTM.
- We report both the standard measurement and simply L/min.

Clear Water Flow Rate

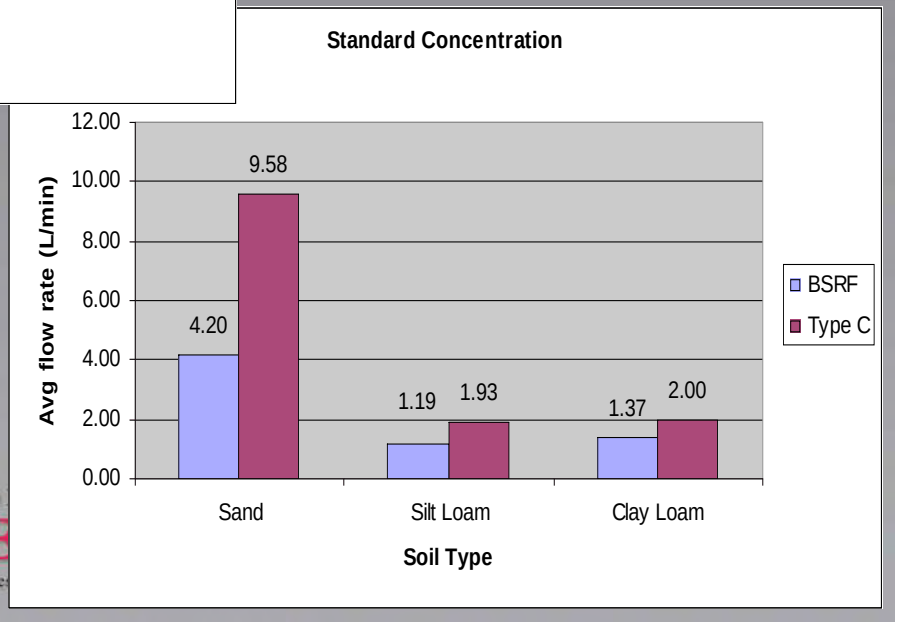


No significant difference

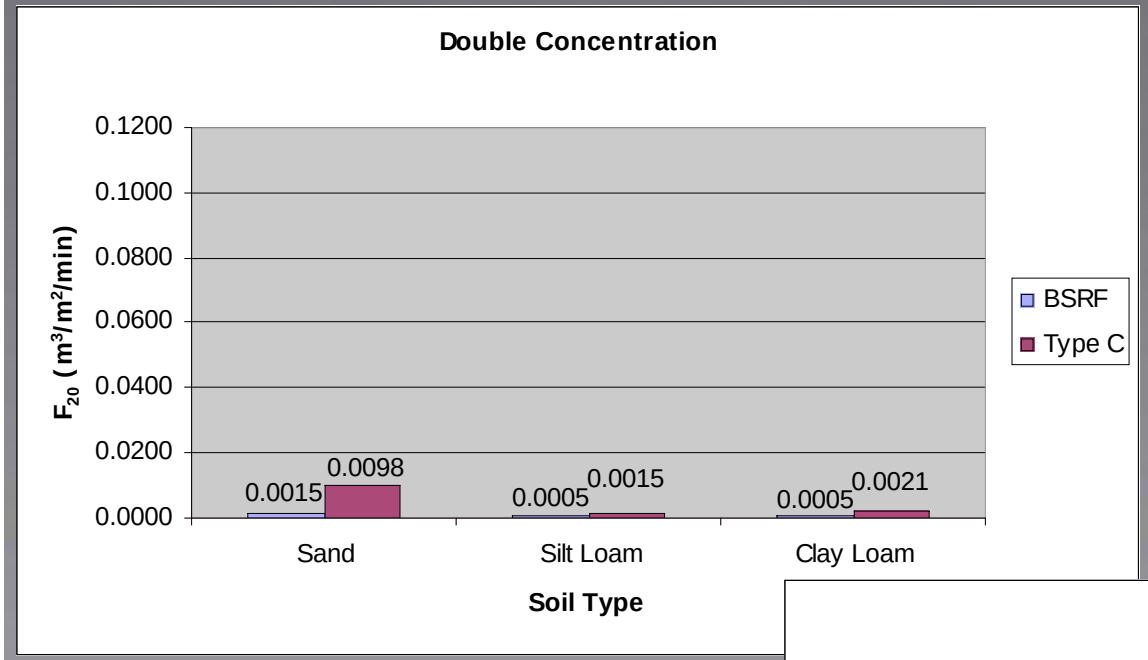
Flow Rate



Type C had higher flow rate with sediment.
Flow rate much lower on silt and clay.

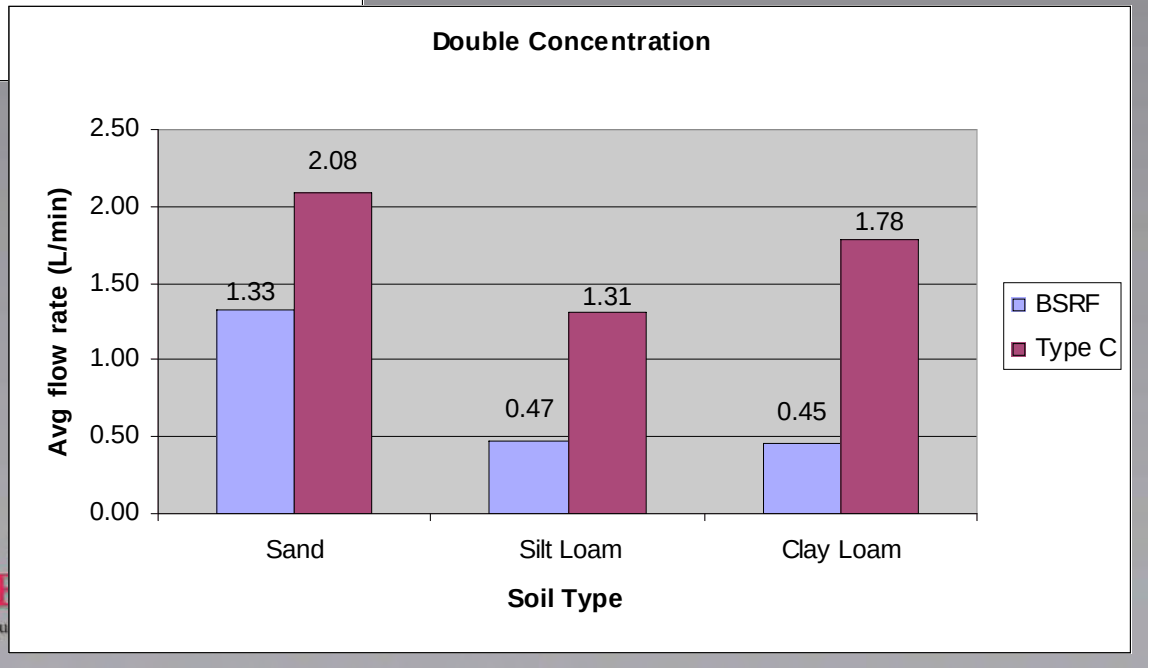


Flow Rate



Flow rates lower at double conc.

Less difference between soil types.



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Flow Rate Conclusions

- The type C silt fence had higher average flow rates for all soil types in both the standard (2890 ppm) and double (5780 ppm) concentrations but not the clear.
- BSRF had a more than 60% reduction in flow rate when running a double concentration after the standard concentration for finer textured soils while the type C had less than 35% reduction.
- Sediment on the fence appeared to influence flow rate.

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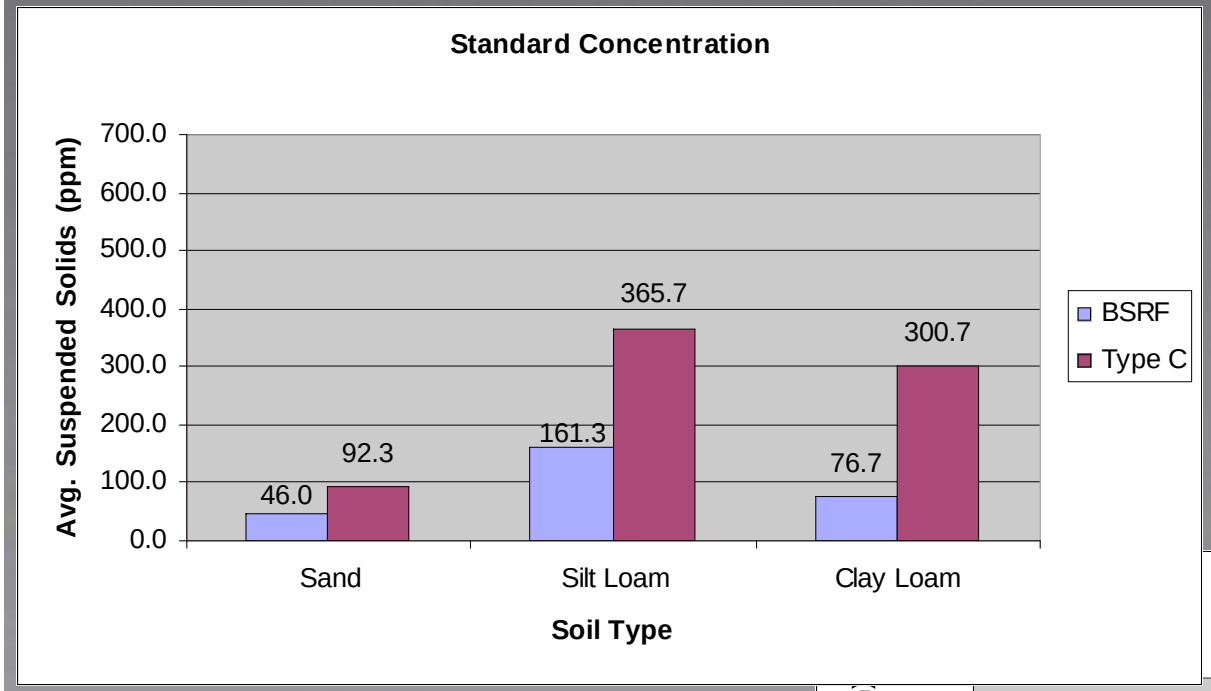
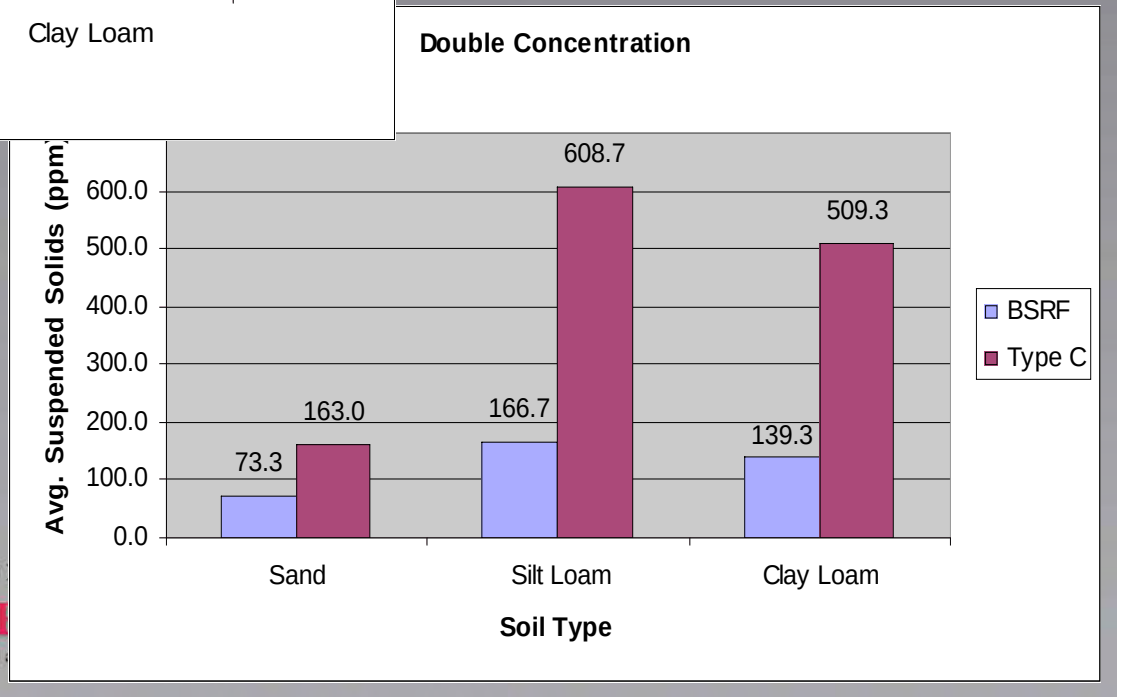
Suspended Solids (S_s) and Filter Efficiency (F_e)

- Standard states that only Filtering Efficiency should be reported.
- We report Efficiency and Suspended Solids concentration and Turbidity of effluent.
- With low slope, considerable amounts of sediment settled out prior to even reaching the silt fence.

Suspended Solids in Effluent





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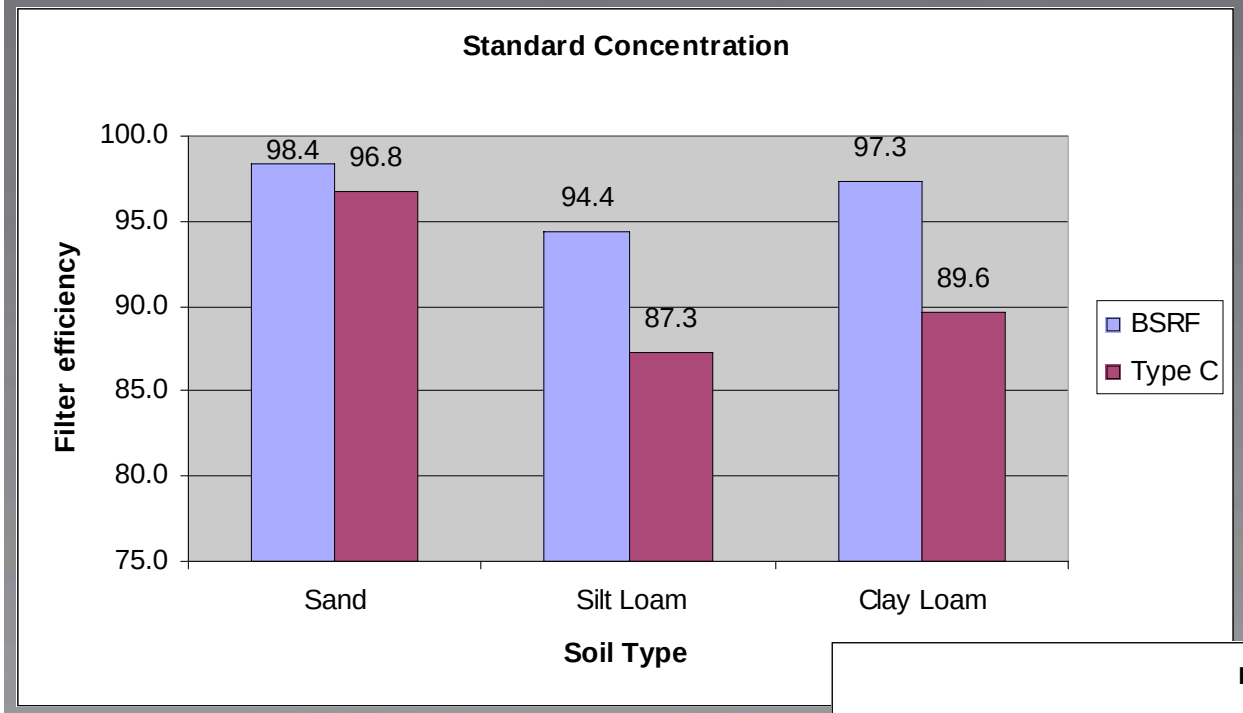
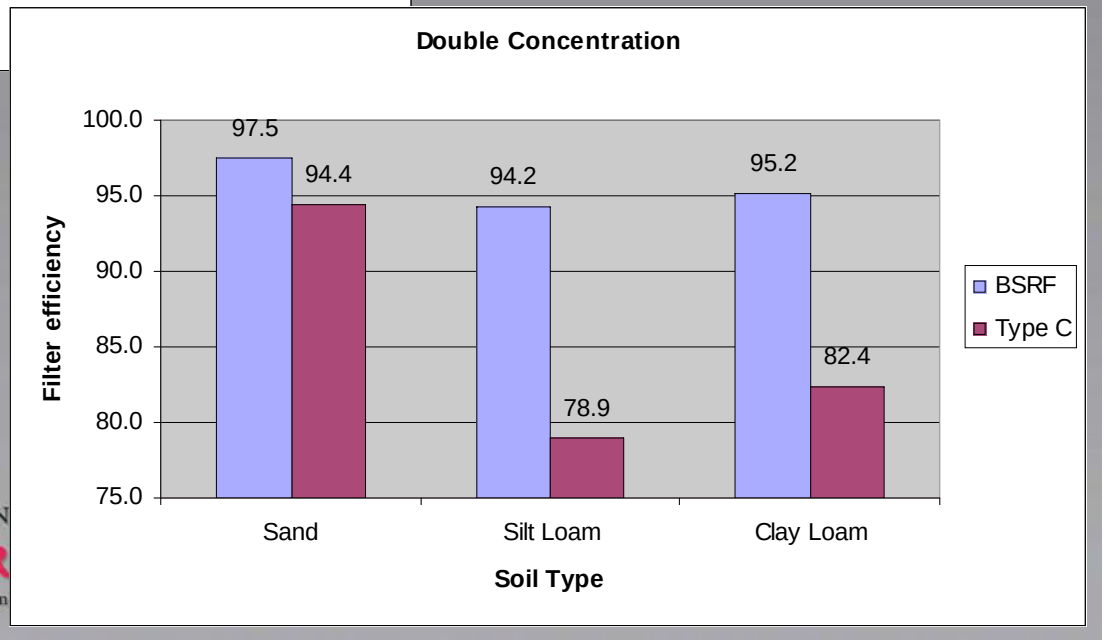
Filter Efficiency





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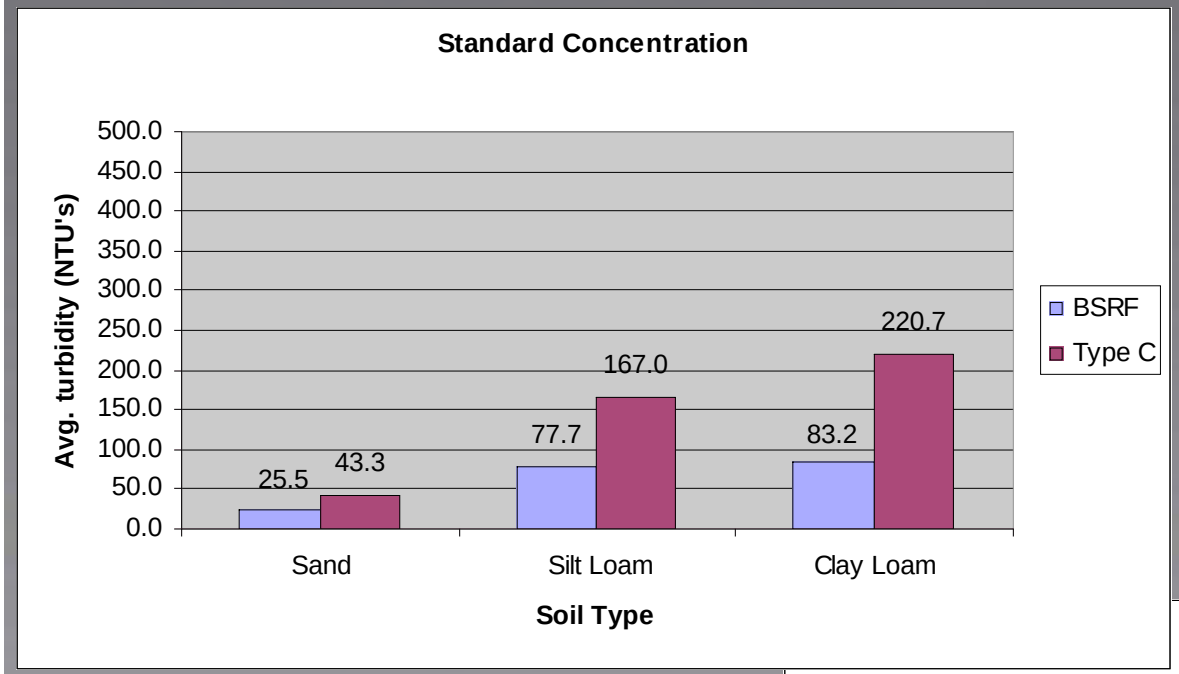
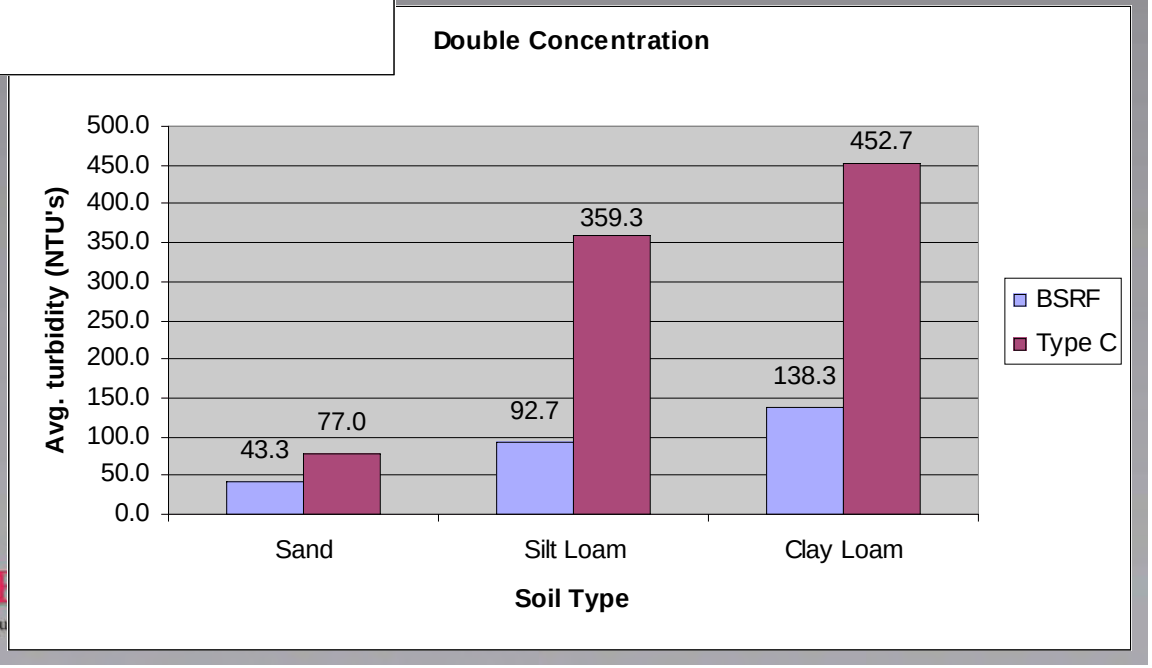
Turbidity





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Results for Filtering Efficiency

- The BSRF proved more efficient at removing suspended solids and turbidity for all soil types at both the standard and double concentration runs.
- BSRF reduced suspended solids values 2 to 3 times lower than the type C fence.
- BSRF retained its filtering efficiency for the double concentration while the type C lost 12 to 15% of its efficiency on the finer textured soils.
- Turbidity results mirrored the Suspended Solids data.
- Both fence materials had high filtering efficiencies.

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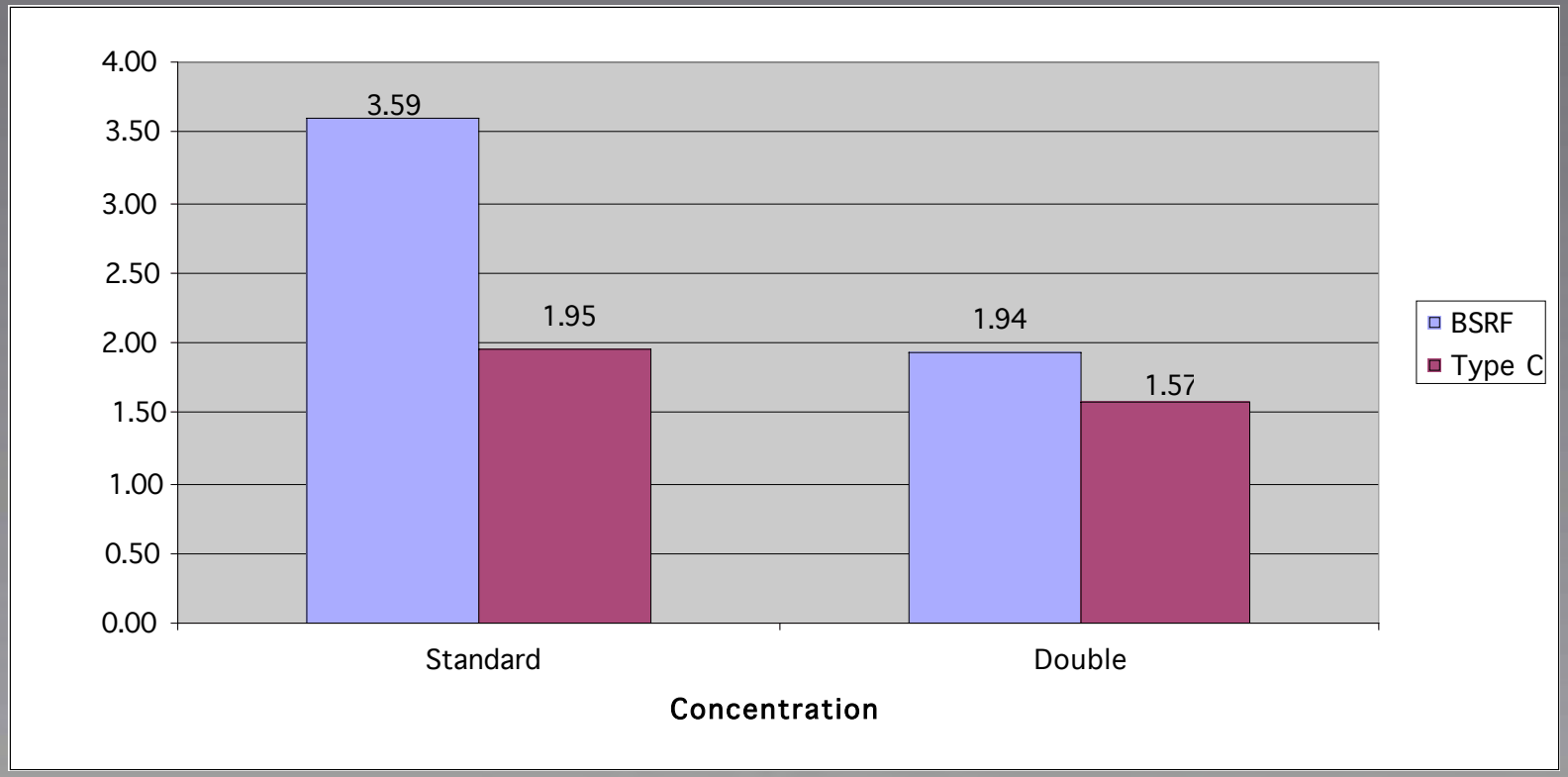
Modifications to Standard

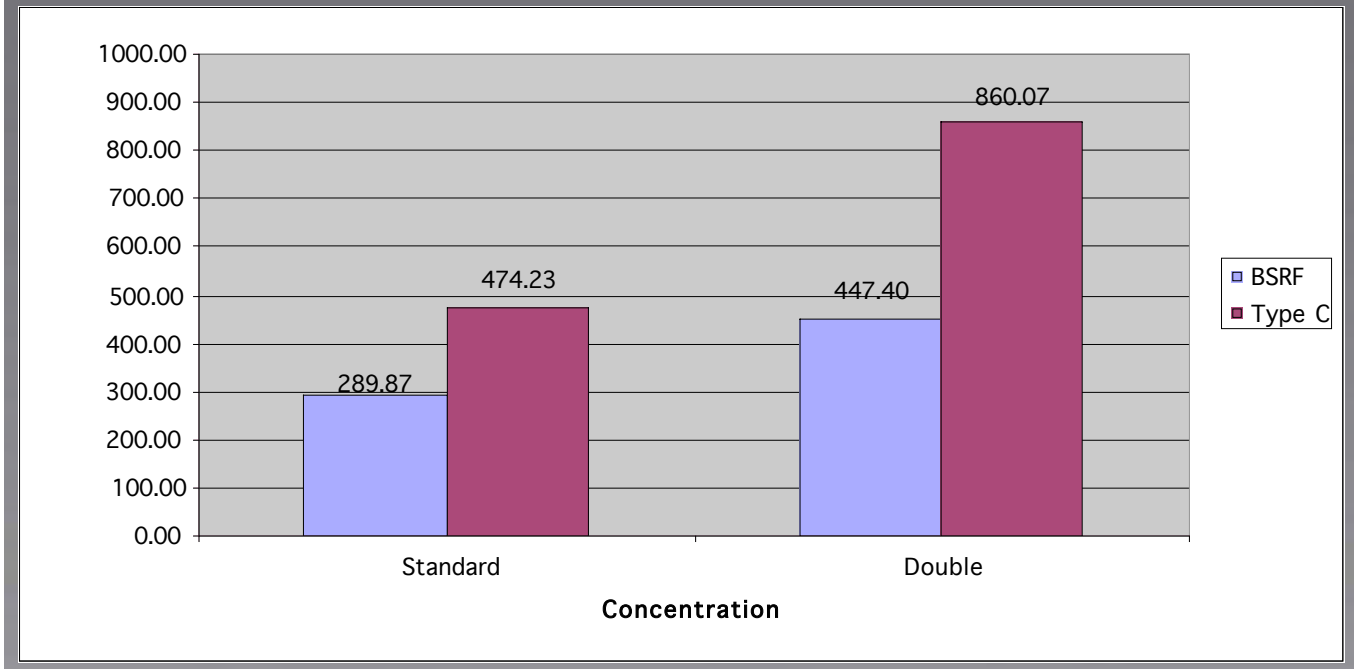
- Since Filtering efficiency was high and significant settling occurred prior to the fence, an additional test was conducted with the flume set at a 58% slope.
- We also wanted to examine the influence of higher hydraulic heads on the various fence materials since this would be important to field applications.
- Same procedures were used.
- Three replicates of the silt loam soil were conducted for each fence material.

Flow Rate @ 58% slope



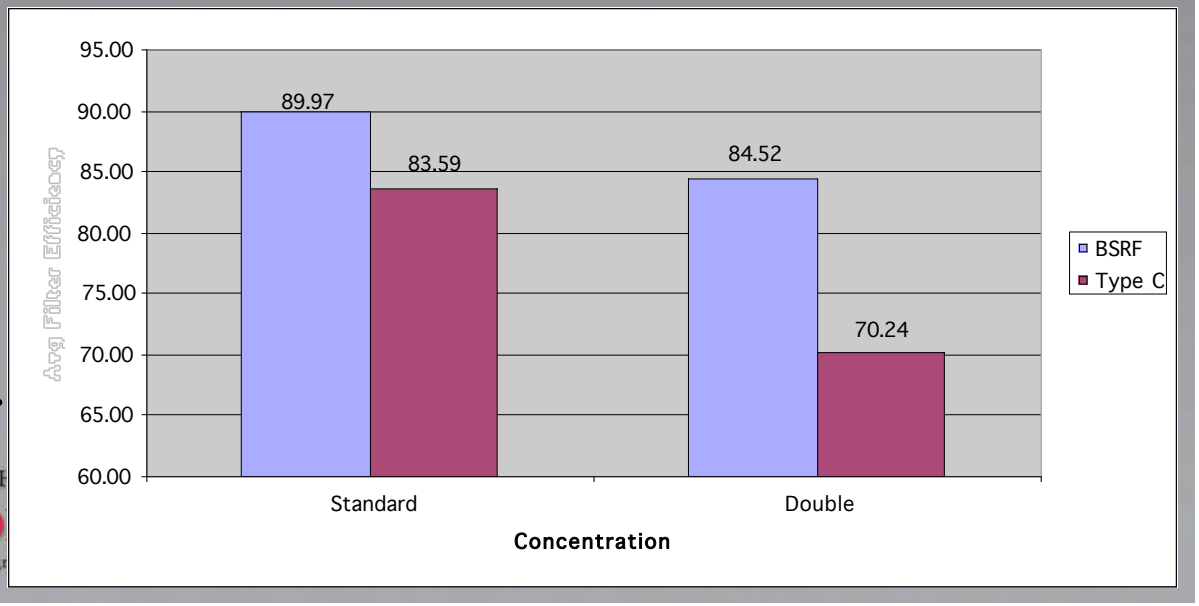
- The higher relief resulted in a greater flow rates for both fence materials. The BSRF fence under high relief conditions exhibited higher flow rates at both the standard and double concentrations.

Performance @ 58%



Suspended solids were higher and efficiencies lower for both fences.

BSRF was more efficient than the type C though the differences were less pronounced then 8 % slope.



One additional test of effectiveness

- Flume is expensive to construct.
- We tested a new apparatus that could be used to test similar properties.
- 5L of water with same sediment conc.

Results

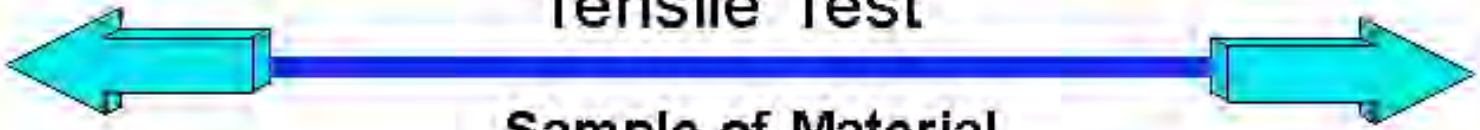
- Flow rates were similar between BSRF (0.27 L/min) and Type C (0.22 L/min) although the Type C had a slightly higher clear water flow rate (22 to 19 L/min).
- BSRF had a higher filtering efficiency (95% to 88%) and percent reduction in turbidity (82% to 60%) than type C fence materials.
- These results were comparable to the flume test results at 8%.

OK, so it filters better and flows at comparable rates, Is it strong enough though?

A Southern Baptism

Tensile Test on Geotextiles To Determine Modulus of Elasticity

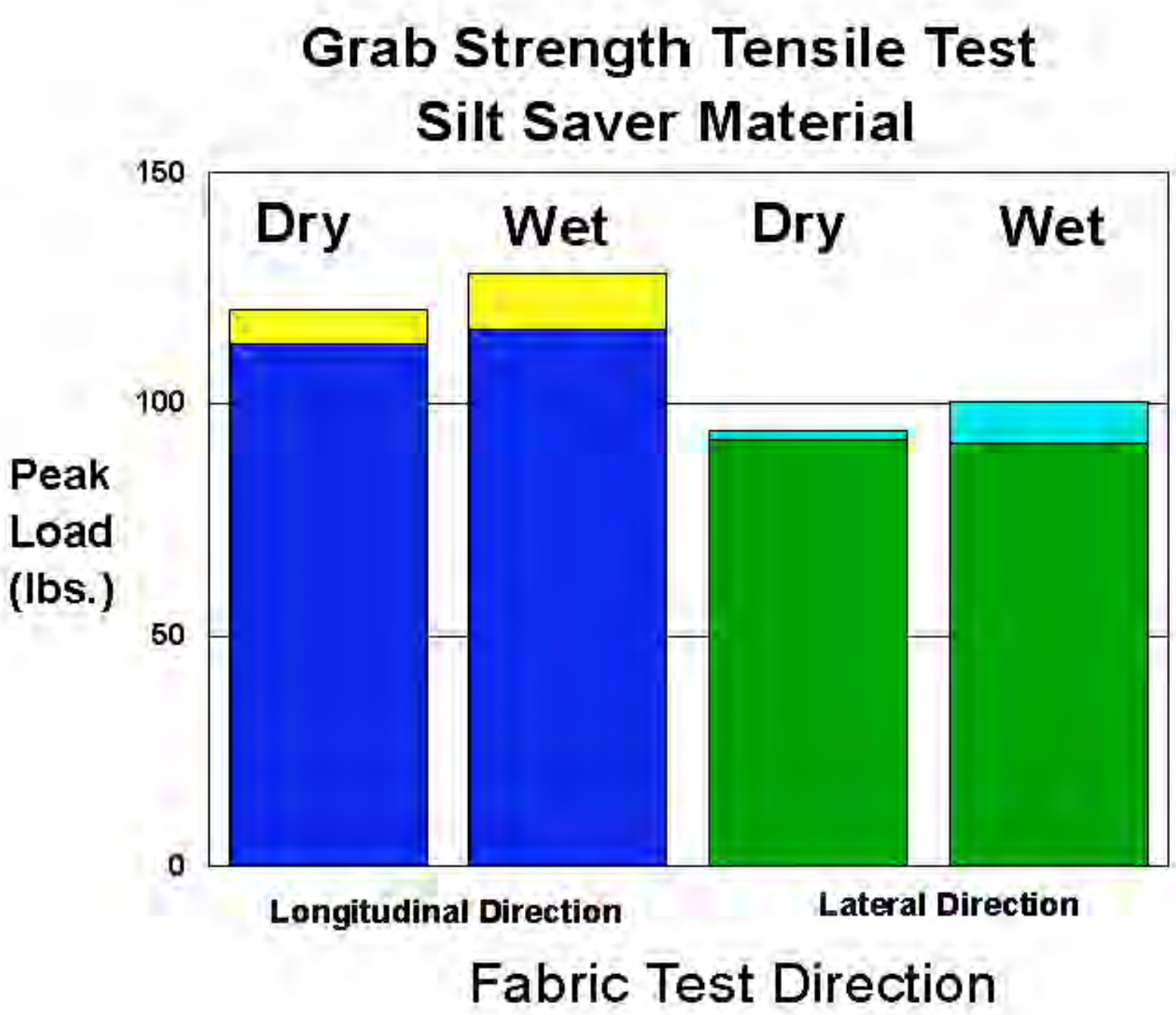
Tensile Test



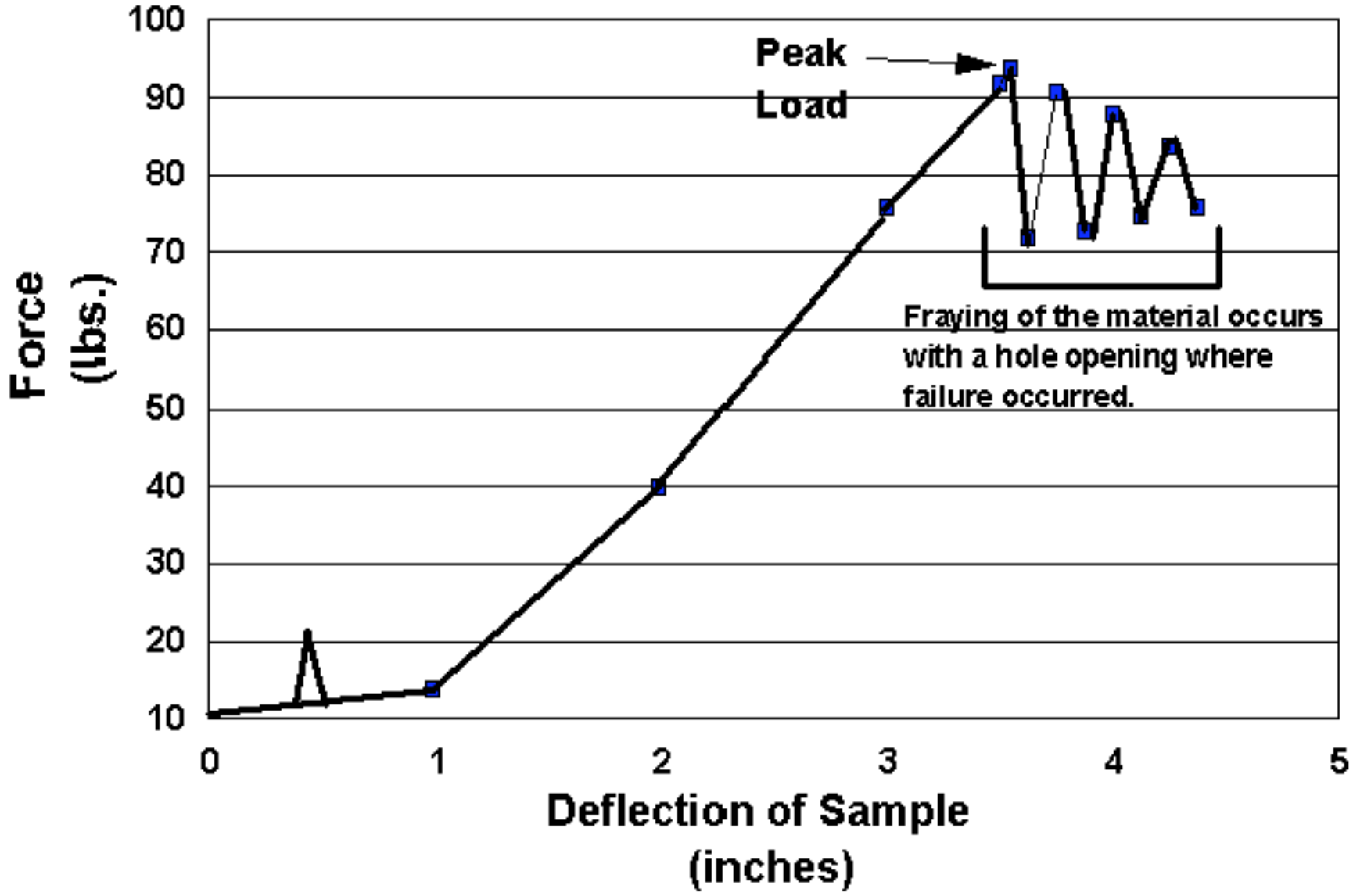
Sample of Material
4 inches long
4 inches wide

Material tested to failure
Test Duration: 20 sec.
Loading Rate: 15 inches/minute
Test Direction: Longitudinal and Lateral Direction of the Fabric
Test Condition: SamplesTested Under Both Wet and Dry Test Conditions

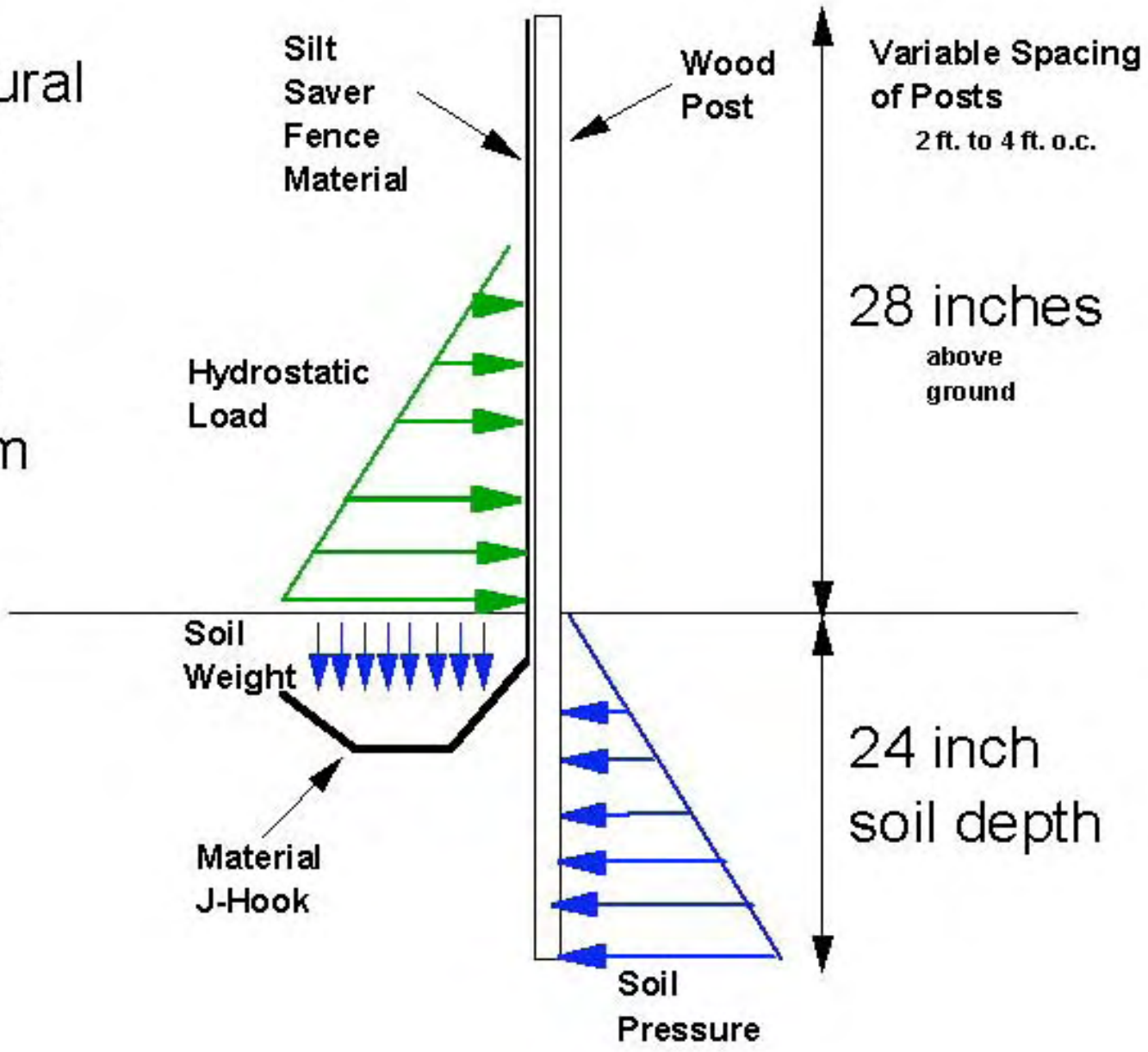
Number of Samples: 7 samples per test condition


Grab Strength Tensile Test
Silt Saver Material
150
100
50
0
Peak Load (lbs.)
Dry
Wet
Dry
Wet
Longitudinal Direction
Lateral Direction
Fabric Test Direction

Typical Response

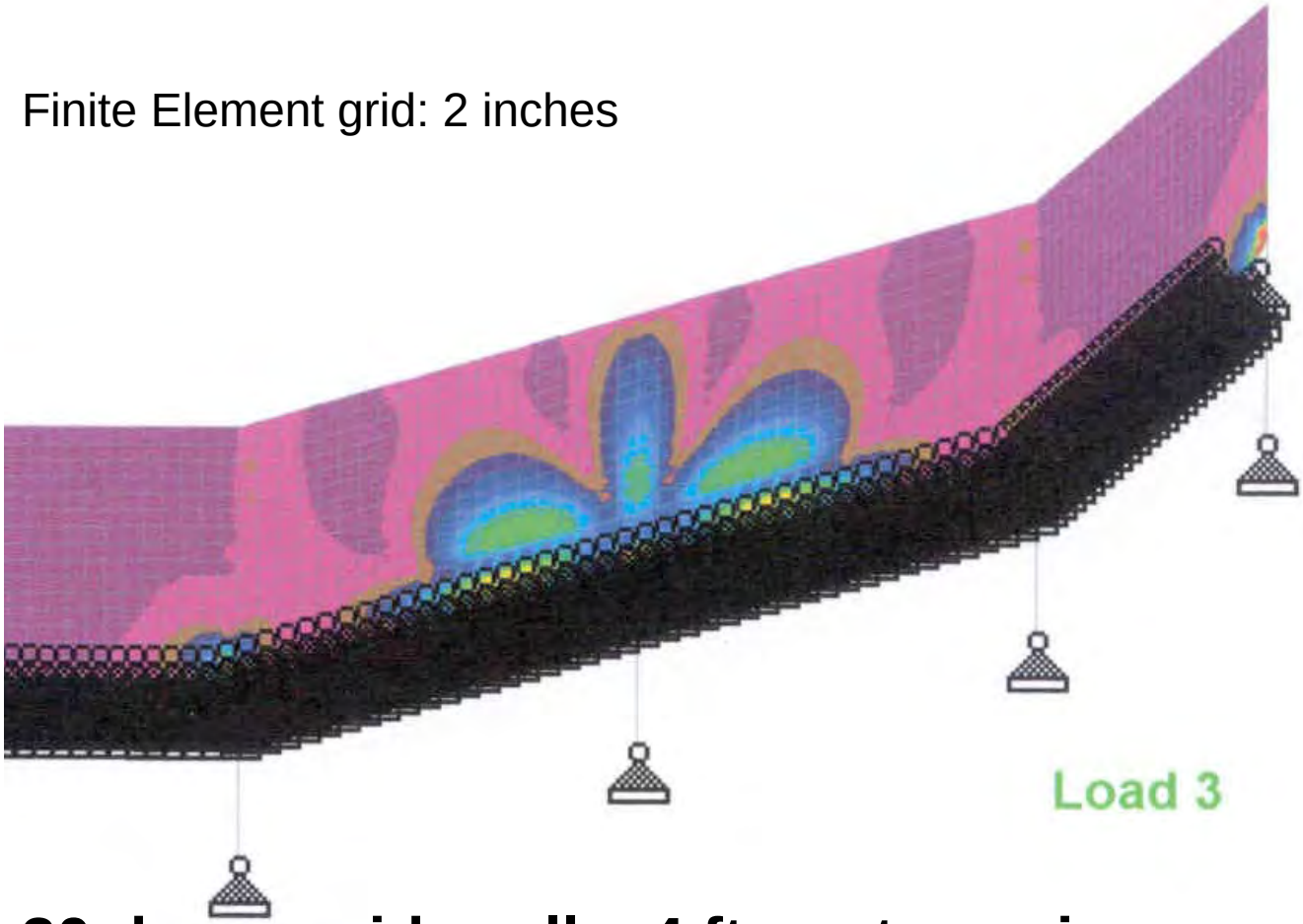


Structural Model Of Silt Saver Fence System



Modeling of Loads on fence

Finite Element grid: 2 inches



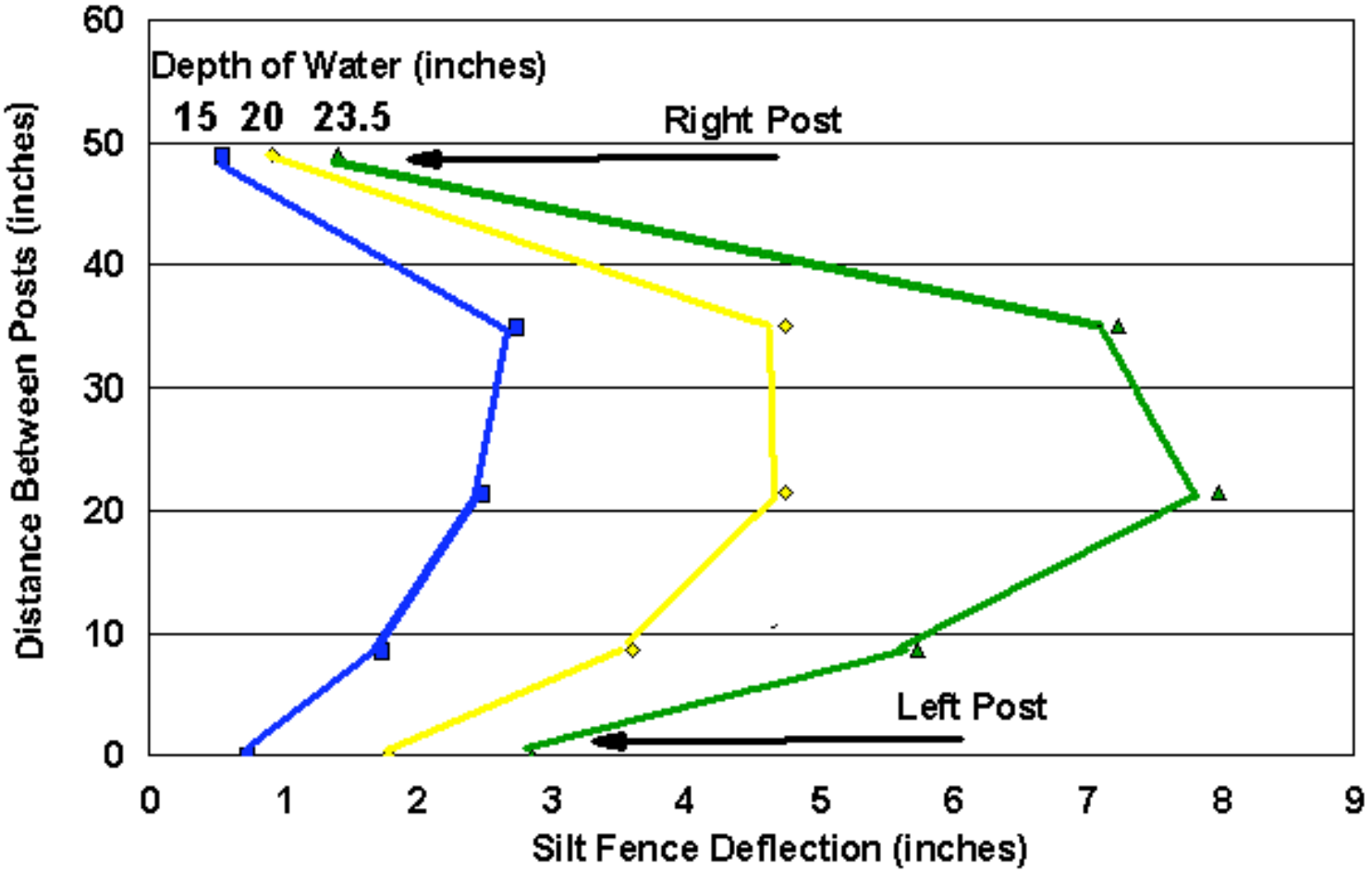
30 degree sidewalls, 4 ft post spacing

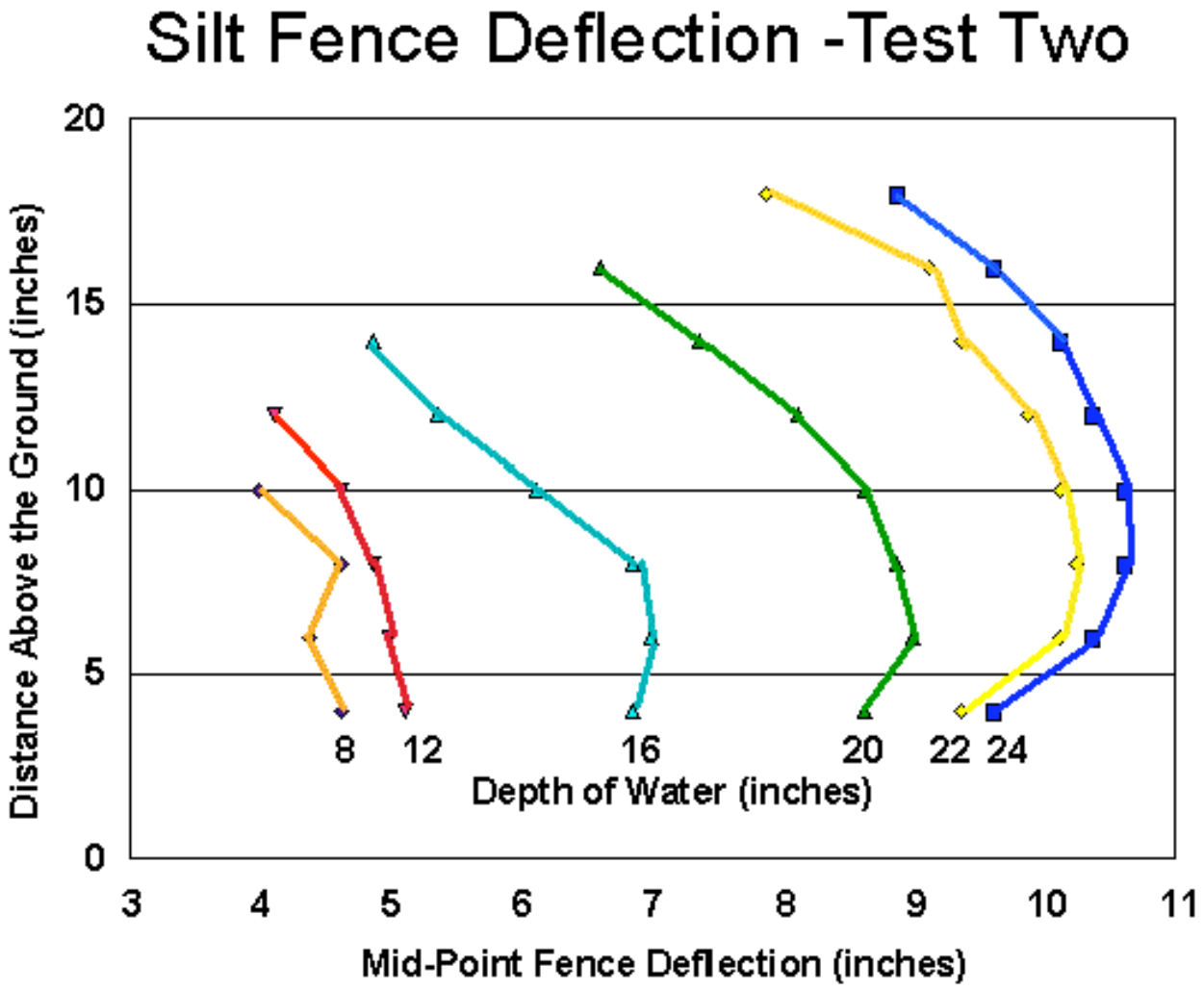
Hydrostatic load of 8 inches

Test One

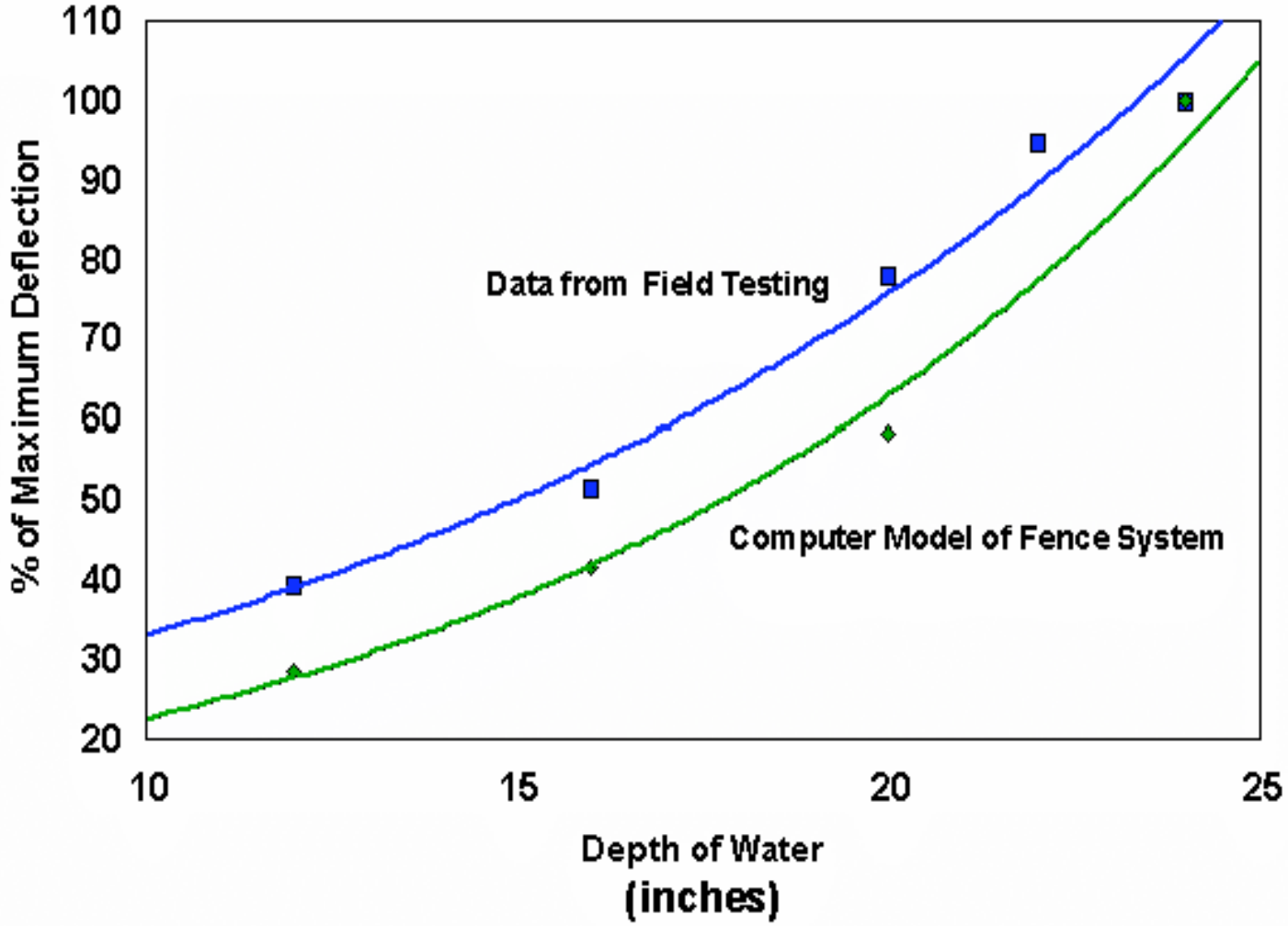
Silt Fence Deflection

at 20 inches Above the Ground




Silt Fence Deflection -Test Two
Distance Above the Ground (inches)
20
15
10
5
0
3
4
5
6
7
8
9
10
11
Mid-Point Fence Deflection (inches)
8
12
16
20
22
24
Depth of Water (inches)

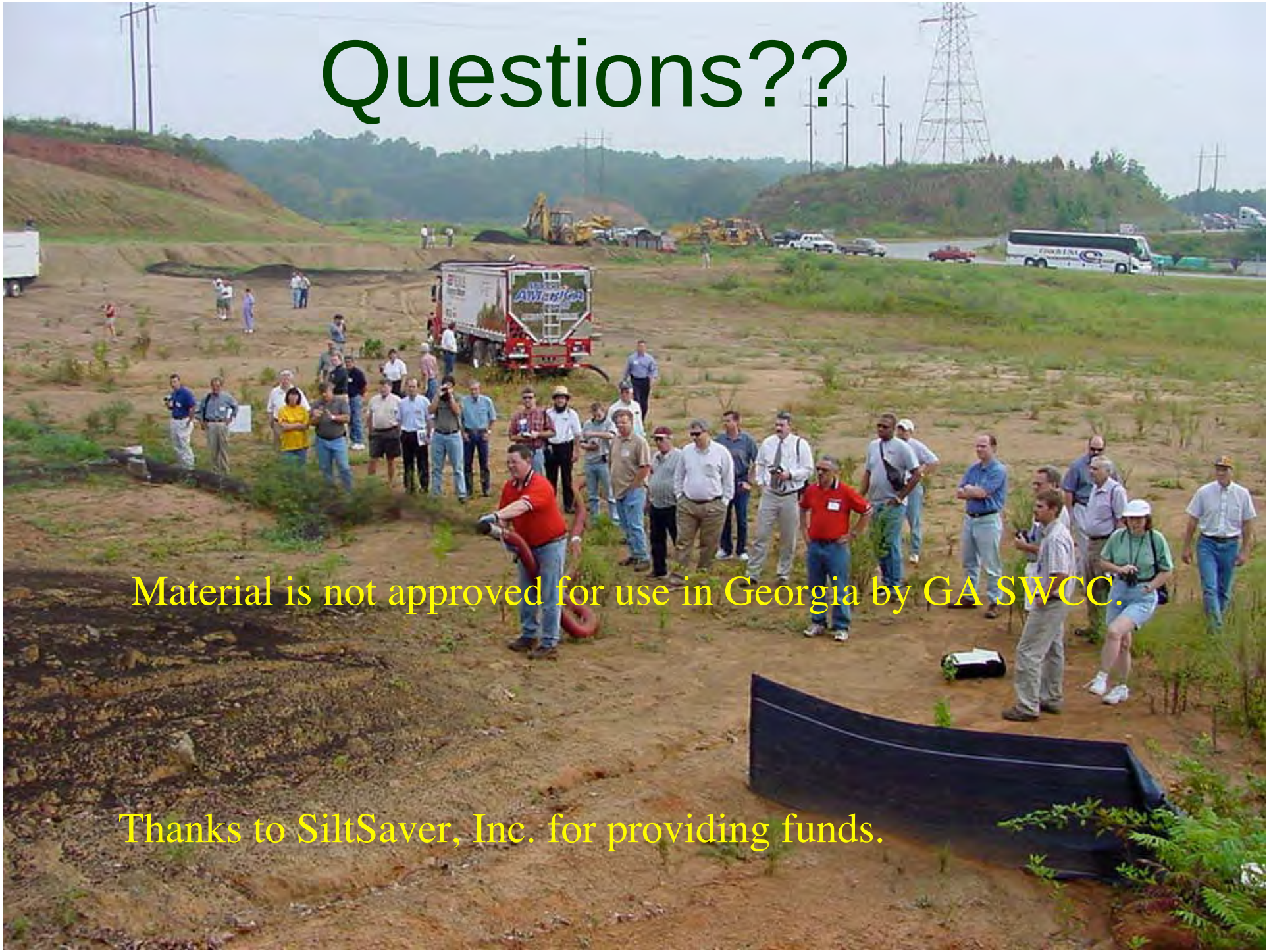
Model Validation



Strength Conclusions

- BSRF fence withstood loads that would normally be encountered in the field.
- While the fabric did not meet GA DOT specs for tensile strength or deflection, the design appears adequate.
- Biodegradable design offers environmental and safety benefits that should be considered.
- Modeling led to design improvements.

Questions??



Material is not approved for use in Georgia by GA SWCC.

Thanks to SiltSaver, Inc. for providing funds.