IMPROVING FINE GRAINED SOILS USING FLUID AND FIBER REINFORCEMENT

Research Team

- Kenan Hazirbaba, UAF
- Rodney Collins, Graduate Student
- Billy Connor, AUTC
- Duane Davis, Undergraduate Student

Funding

- US DOT
- FHWA
- Alaska Department of Transportation and Public Facilities
- Midwest Industries
- Peak Oil Services

The Problem

- Gravel in western Alaska scarce
- Can cost up to $800/ cubic meter
- In-situ material ranges from fine sand to organic silts
- Terrain: River delta with numerous slough, ox-bows and lakes.
- Climate: Coastal

Use of Marginal Material

- Increase the use of local material without sacrificing performance
- Use of Fibers and Soil Stabilizers most promising
- Completed first test section at Horseshoe Lake
- Working with DOT on possible implementation at Kwigillingok

Kwigillingok Runway

Kwigillingok Village Road

Research Approach

- Characterize untreated soils
- Determine optimum fiber content
- Compare fluid additives
- Field Testing

Components

- Geofibers
- Synthetic Fluid
- Soil

Geofiber

GEOFIBERS®

- **1”-3” Long Discrete Fibers**
- **Light Weight**
- **High Tensile Strength**
- **Fibrillated & Tape fibers**

Geofiber Applications

- Slope Repair / Slope Stabilization
- Dam / Levee Construction
- Veneer Reinforcement
- Sub Grade Stabilization
- Pavement Base Reinforcement
- Chemically Treated Base Reinforcement
- Landfill Liners, Caps, & Covers

Synthetic Fluid

- Earth Armour Limited – Arctic
- Soil Sement
- Others to follow

Soil Tested

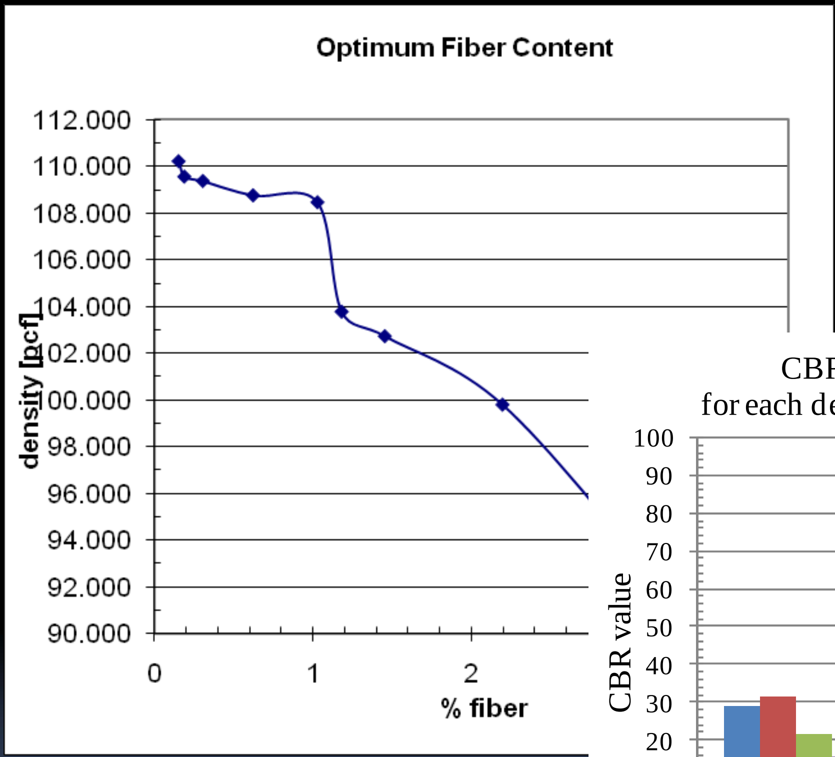
- Cape Simpson: Uniformly graded silt
- Bethel: Fine Silty Sand
- Horseshoe Lake: Fine poorly graded medium Aeolian sand
- Fairbanks Silt: poorly graded Aeolian silt
- Ottawa Sand: coarse sand

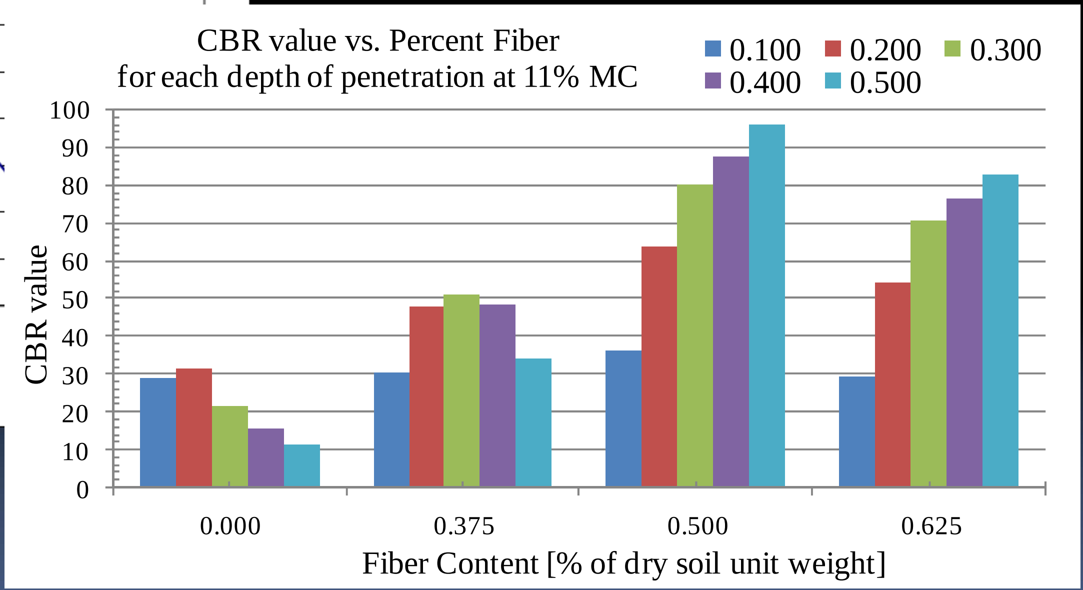
CBR Test

- Compare the displacement to the load
- Area of piston is known
- Resultant stress is found
- CBR number is calculated

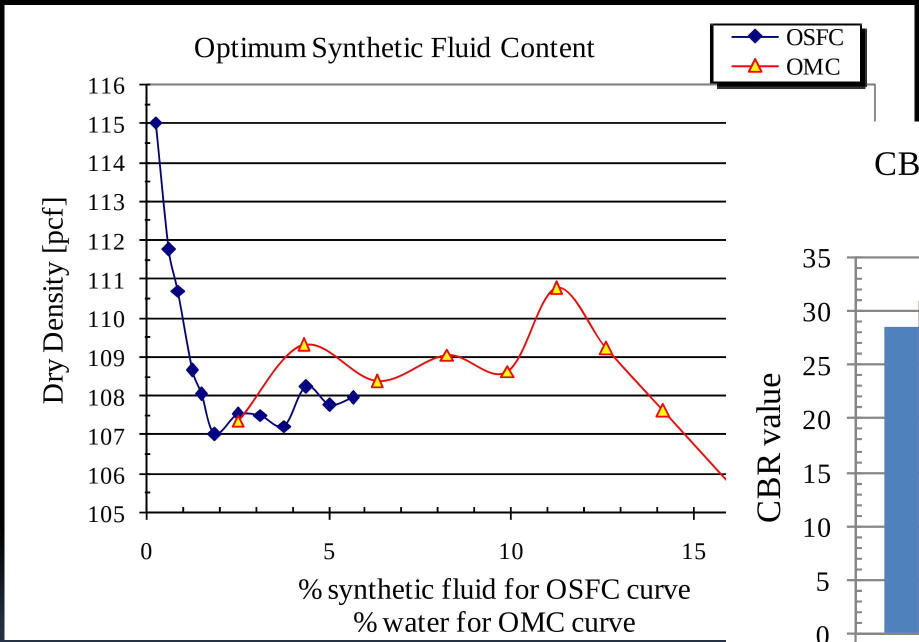
Example Mixture of Soil, Geofibers, and Water

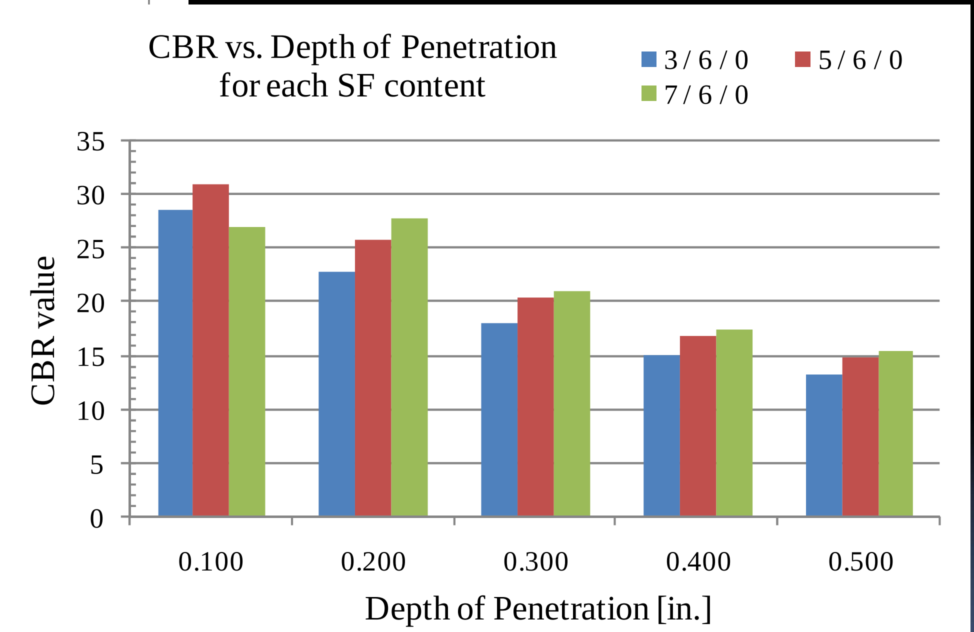
Optimum Fiber Content (Bethel)



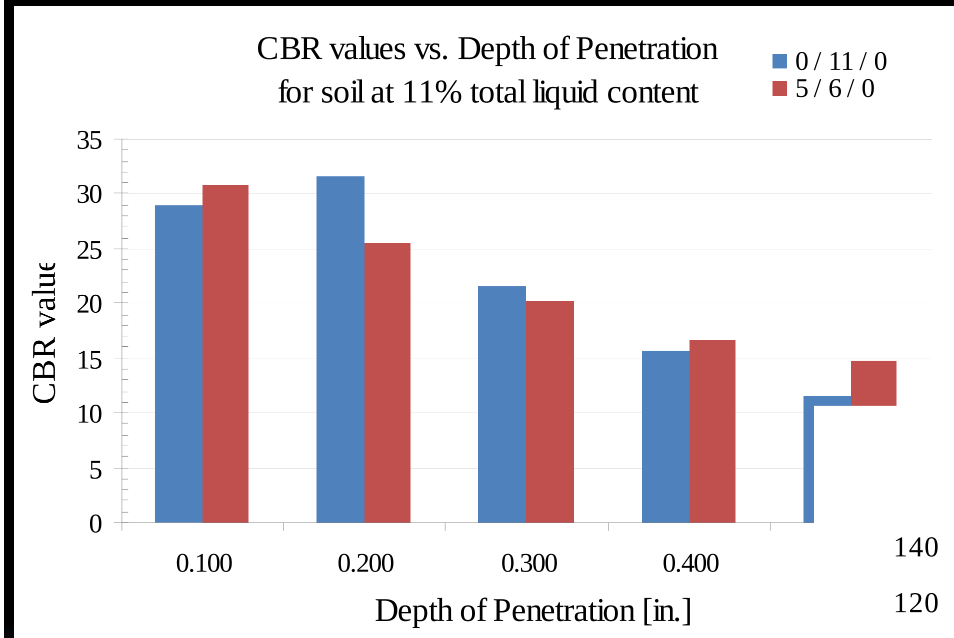


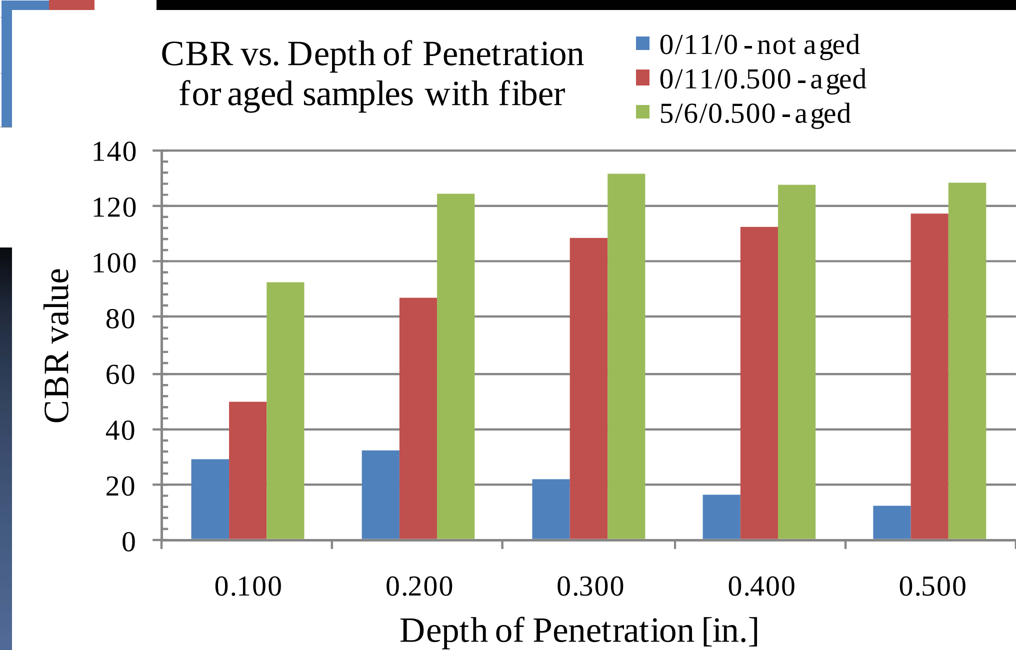
Optimum Synthetic Fluid Content?



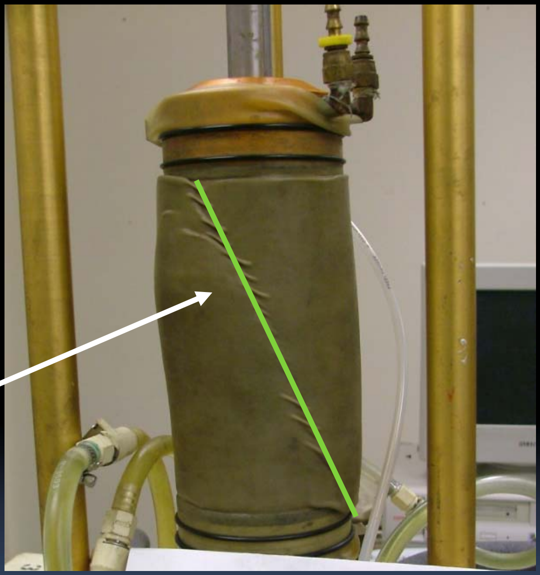


Effect of Earth Armour Fluid (Bethel)





UU Triaxial Failure Modes



Distinct failure plane

Compacted/unimproved sample

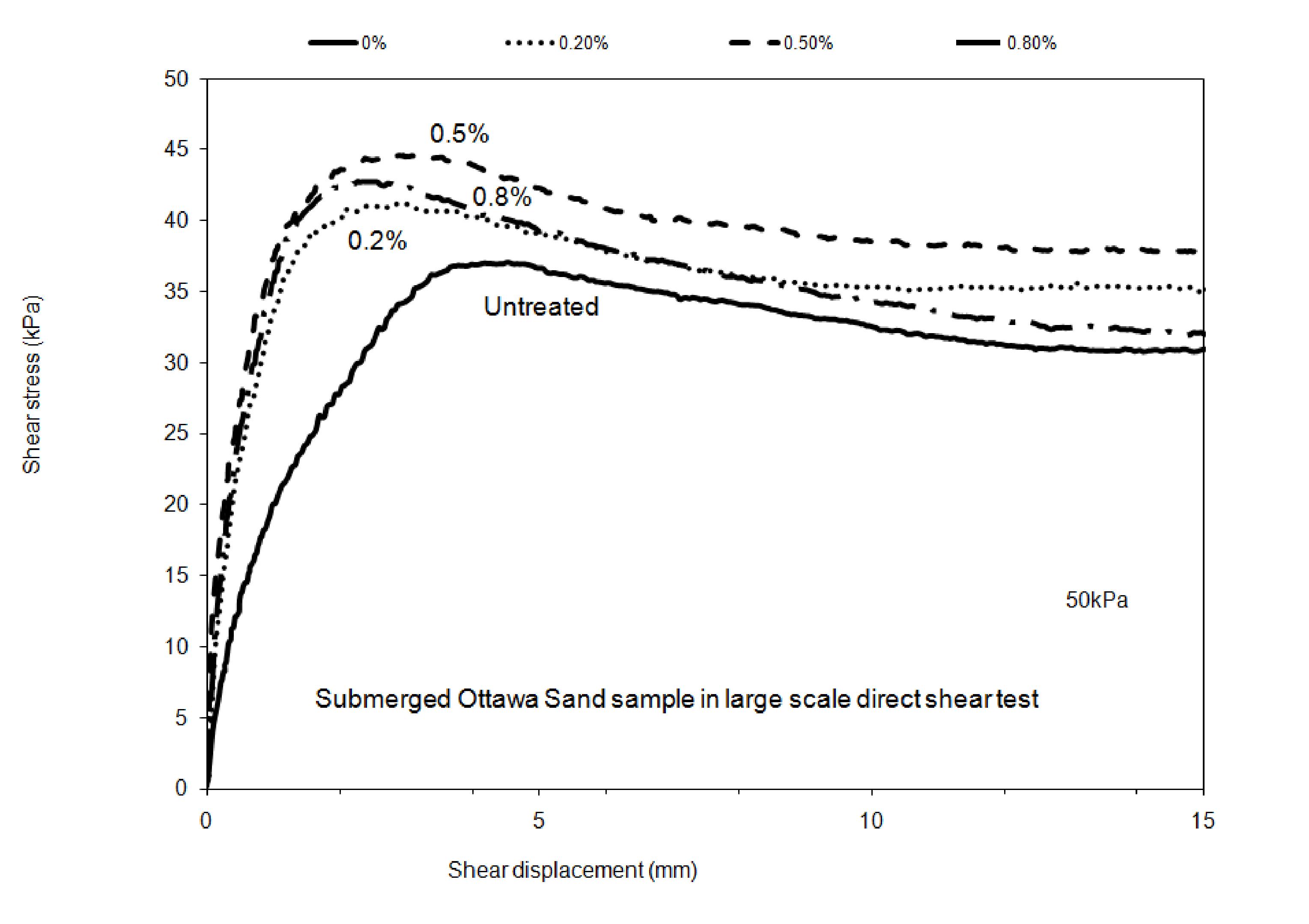
No distinct failure plane- bulging out

Compacted/geofiber-reinforced sample

UU Triaxial Results (Bethel)

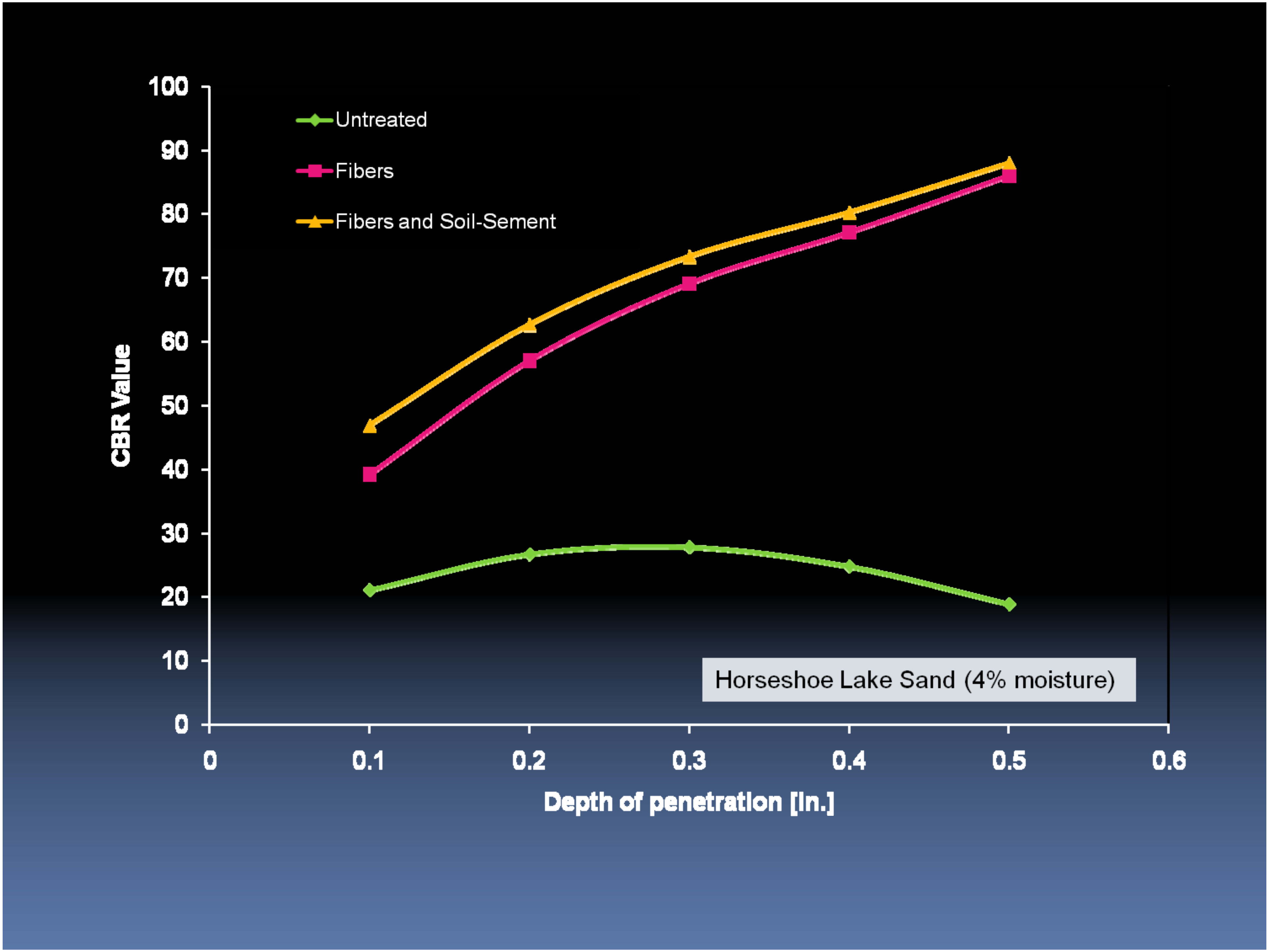
Synthetic Fluid Content,%	Water Content,%	Geofiber Content,%	Friction Angle, degrees	Cohesion, psi
-	11	-	41.8	2.9
-	11	0.5	43.7	23.5
3	6	0.5	48.5	13.9
5	6	0.5	53.6	11.2
7	6	0.5	55.6	4.9

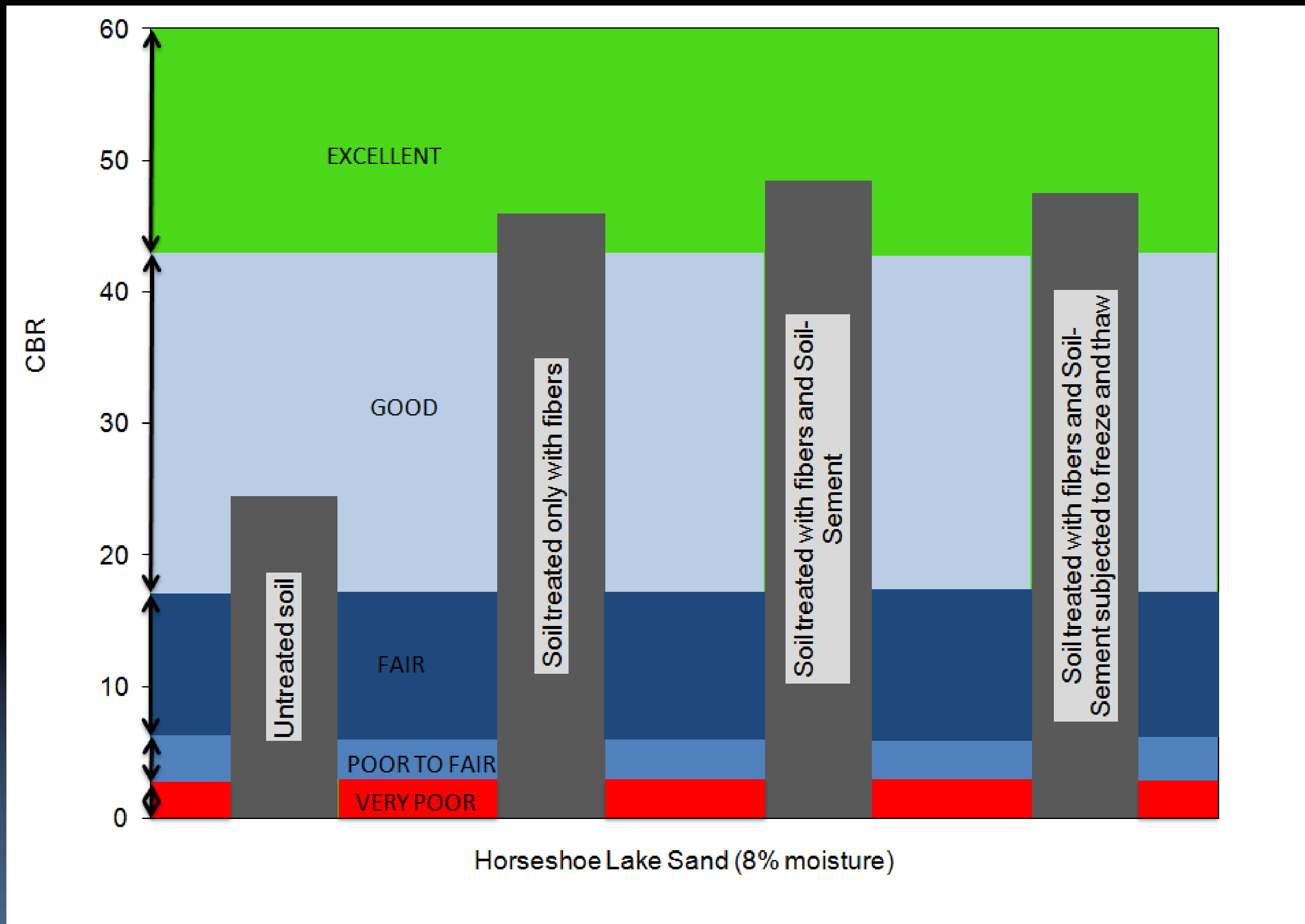
Typical Direct Shear Tests



Horseshoe Lake Test Section

- **Located Near Big Lake**
- **Medium Aeolian sand**
- **Low Traffic**


Untreated
Fibers
Fibers and Soil-Sement
CBR Value
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Depth of penetration [in.]
Horseshoe Lake Sand (4% moisture)

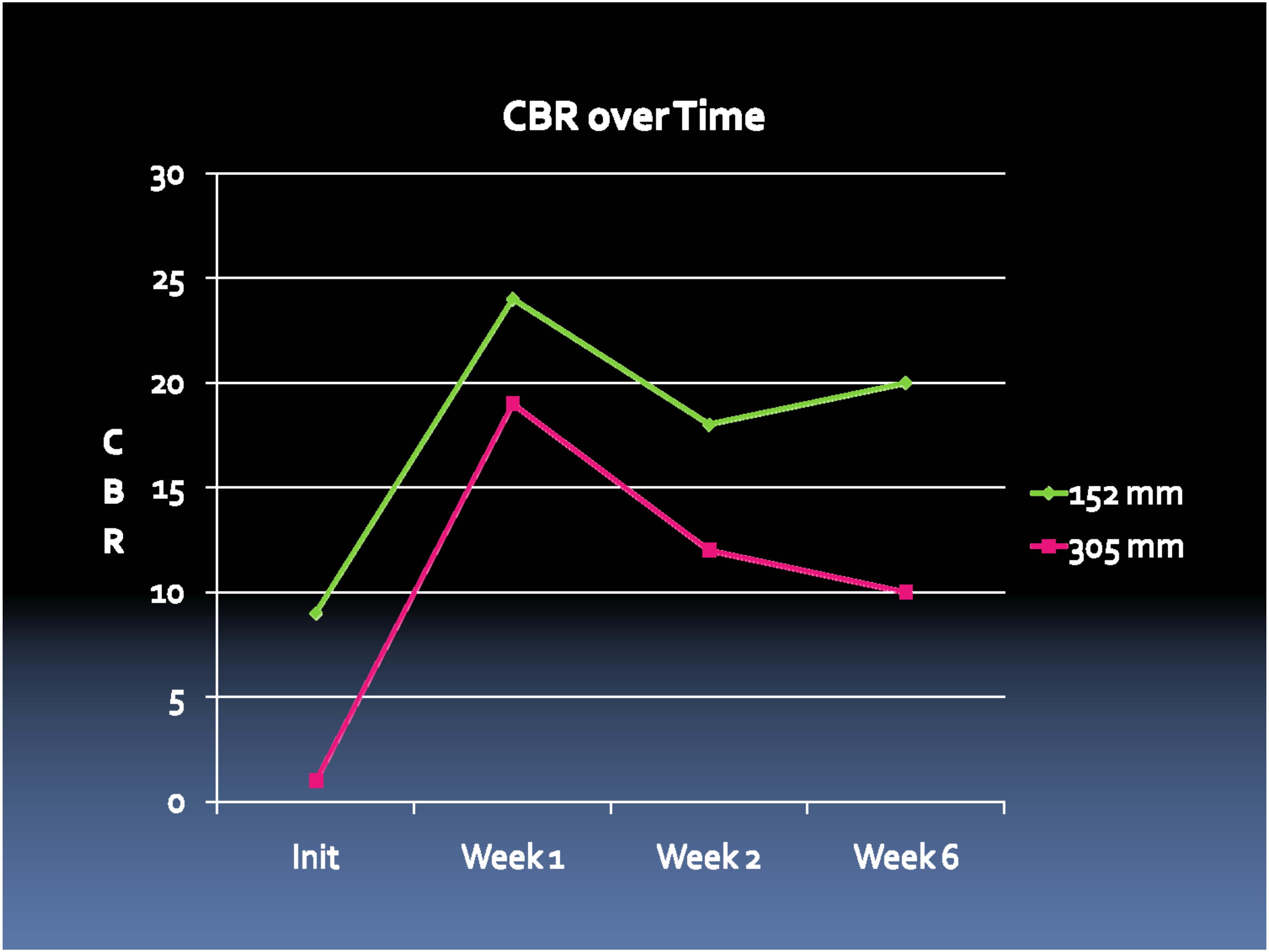


CBR
60
50
40
30
20
10
0
EXCELLENT
GOOD
FAIR
POOR TO FAIR
VERY POOR
Untreated soil
Soil treated only with fibers
Soil treated with fibers and Soil-Sement
Soil treated with fibers and Soil-Sement subjected to freeze and thaw
Horseshoe Lake Sand (8% moisture)

Construction

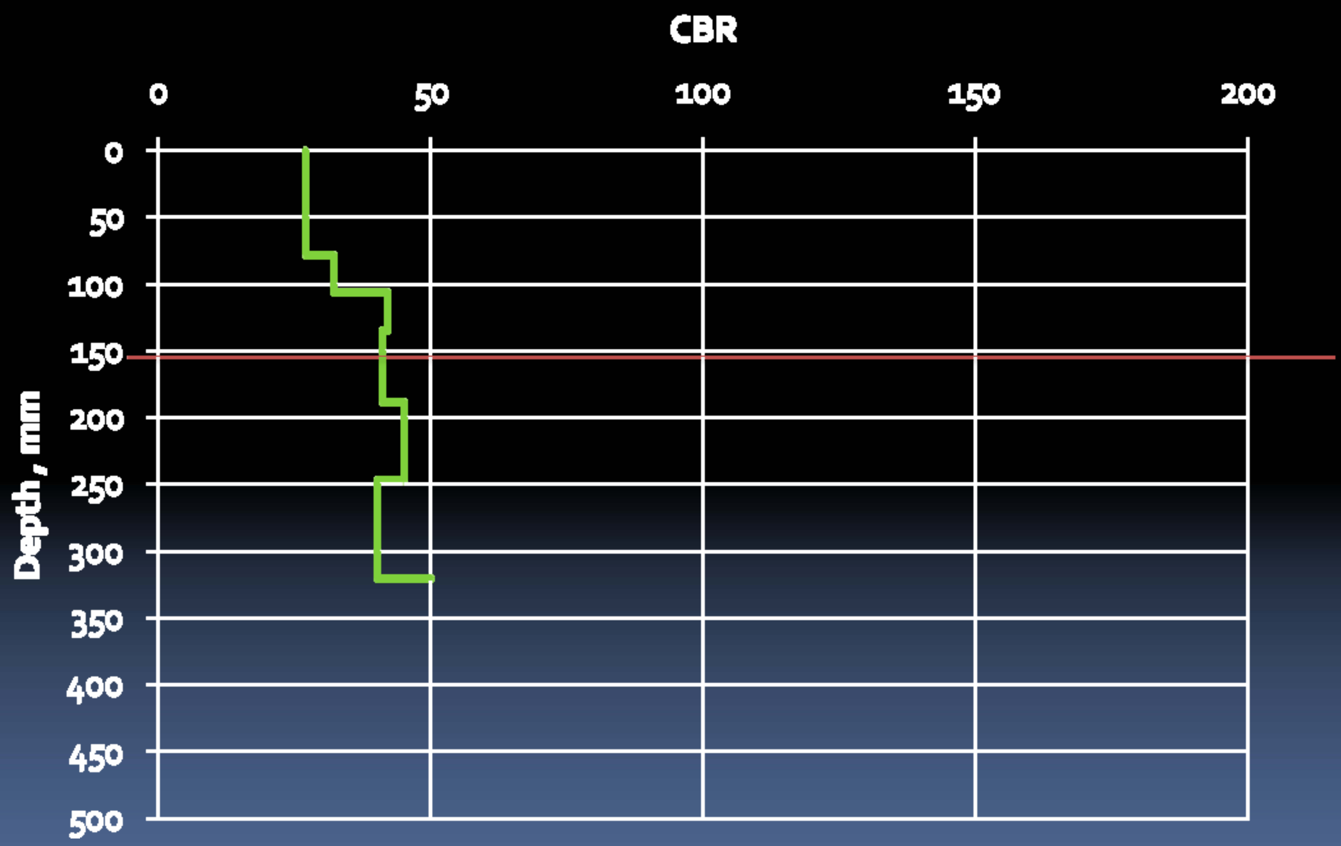
- One 6 inch section and one 300 mm in section each 85 meters length 6 meterswide
- 0.4% fiber content
- 25 liters of soil sement/cubic meter

Construction Steps



CBR over Time
30
25
20
15
10
5
0
C
B
R
Init
Week 1
Week 2
Week 6
152 mm
305 mm

Typical DCP Curves



CBR @ 100mm w/ DCP

150 mm section	28
300 mm section	41
30 m before	22
30 m after	28

Observations to Date

- After six weeks, no damage by traffic
- Surface more resistant to abrasion than adjacent sections
- Surface appears to be water resistant
- More loose fiber than expected


Test Section Cost about
$200/cy
(gravel cost @ Kwig: $800/cy

Study Preliminary Conclusions

- Optimum Fiber Content 0.3 to 0.5%
- Impact of fluid is variable
- Expect CBR to double with technology
- Treated soil are strain hardening
- Treated silts and sands behave more like sandy gravels
- Finer soils tend to benefit more
- Not applicable to gravels or sandy gravels

Future Research/Goals

- Write an Engineering Design Guide for the use of geofibers and synthetic fluid to stabilize marginal soils (e.g., soils typically found in western Alaska and North Slope)
- Investigate additional soil types encountered in Alaska
- Quantify the synthetic fluid's ability to stabilize soil while undergoing freeze-thaw cycles (i.e., reduce or prevent frost-heave)

Future Research/Goals

- Investigate synthetic fluid mobility in the soil
- More in-depth investigation on the aging
- Observe the effects of geofiber shape and size on soil strength and long-term stability
- Resilient modulus testing for pavement design
- Large scale in-situ testing