Rapid Soil Stabilization Technologies

J.Kent Newman, PhD
Airfields and Pavements Branch
Geotechnical and Structures Laboratory
US Army Engineer Research and Development Center

Objective

- **To employ mats, soil stabilizers, fibers, geotextiles, etc… for rapidly constructing airfield facilities**
  - **Low logistical effort**
  - **Minimal stabilization**
  - **Reduced cure/construction times**
  - **Weatherproofing/dust control**
  - **Repair**

Approach

- **Applied Research (6.2) – Development of promising technologies for soil stabilization**
  - **Polymer/Cement blends**
  - **Fiber/Cement blends**
    - **Synthetic**
    - **Wood/cellulose**
  - **Polyurethanes/Epoxies**
    - **Single and two-component mixtures**
  - **Cold-weather curing of cements**
- **Demonstration Technology (6.3) - Utilize existing technology for military applications**
  - **Scale-up of polymer/cement and fiber/cement stabilization from laboratory to field**
  - **Testing of commercial mat systems for airfield applications**

Products

- **Airfield Matting**
  - Materials
  - Construction and design methodology
- **Dust Control**
  - Materials
  - Application and Construction Methods
- **Soil Stabilization**
  - Materials – Including Freeze-thaw areas
  - Aircraft Specific Thickness Design
  - Construction Methods

Dust Control

ERDC HVS Test Facility

C-130 Wheel, 30,000 Lbs
On 6” of Stabilized Soil

Rapid Stabilization Work Unit Plan

Work Unit Title	PI	Fund Type	FY02	03	04	05	06	07
Rapid Stabilization								
Development of Stabilizers for Accelerated Curing	Newman	6.2						
C-17 Shear-Resistant Stabilizer Development	Newman	6.2						
Dust Control Technologies	J. Rushing	6.2						
Stabilization of Thawing Soils	R. Rollings	6.2						
Rapid MOG Enhancement Technologies	Anderton	6.3						
Stabilization of Thawing Soils Demonstration	R. Rollings	6.3						
Demonstration of Advanced Stabilizer Technologies (C-130)	Newman	6.3						
Field Testing of Advanced Stabilizer Technology (C-17)	Newman	6.3						
Evaluation of Structural Requirements for Stabilized Airfields	Freeman/Gonzalez	6.3						
Maintenance and Repair of Stabilized Layers	Shoenberger	6.3						
Demonstration of C-17 Stabilization Technology	Newman	6.3						

Joint Rapid Airfield Construction

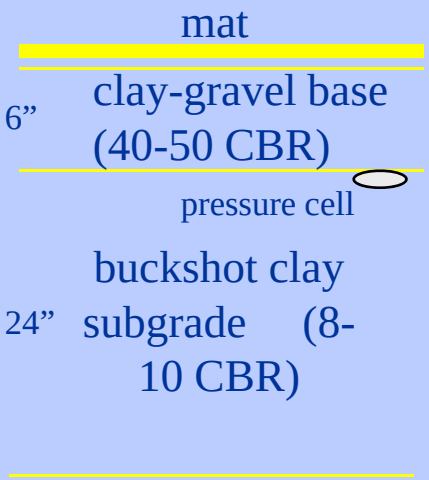
Pertinent Work Units

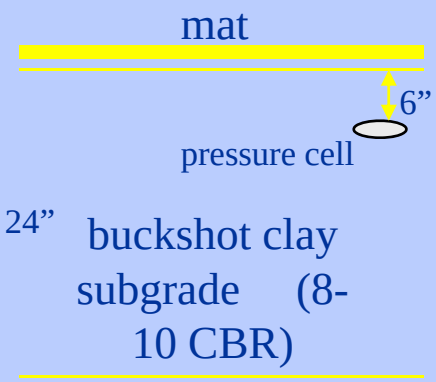
- C-17 Shear-Resistant Stabilizer Development – FY07 End
- Dust Control Technologies – FY07 End
- Stabilization of Thawing Soils – FY05 End
- Rapid MOG Enhancement Technologies – Need Extension through FY06
- Demonstration of Advanced Stabilizer Technologies (C-130) – FY05 End
- Field Testing of Advanced Stabilizer Technology (C-17) – FY06 End
- Evaluation of Structural Requirements for Stabilized Airfields – FY06 End
- Maintenance and Repair of Stabilized Layers – FY06 End
- Demonstration of C-17 Stabilization Technology – FY06 New Start

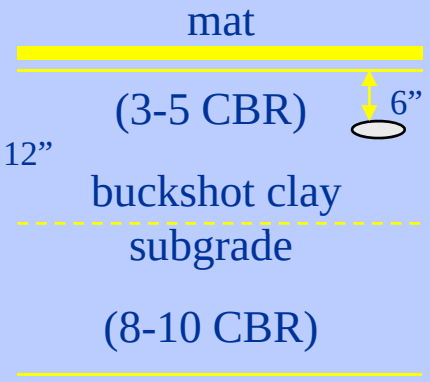
Accomplishments Thru FY04

- **Progress:**
  - Tested Commercial Mat Types Over Different Soil Strengths
    - C-130 contingency weights
  - Rapid Soil Stabilizers
    - Fibers and fast-setting cements
    - Polymers and fast-setting cements
  - Improved Dust Abatement
    - Best construction techniques
    - Best application equipment
    - Evaluated commercial products
  - Developed Cold Weather Stabilizers
    - Admixtures in cement for curing under freeze-thaw conditions
  - Ft. Bragg Demo

Ft. Bragg Demo – Mat testing for C-130 Loads







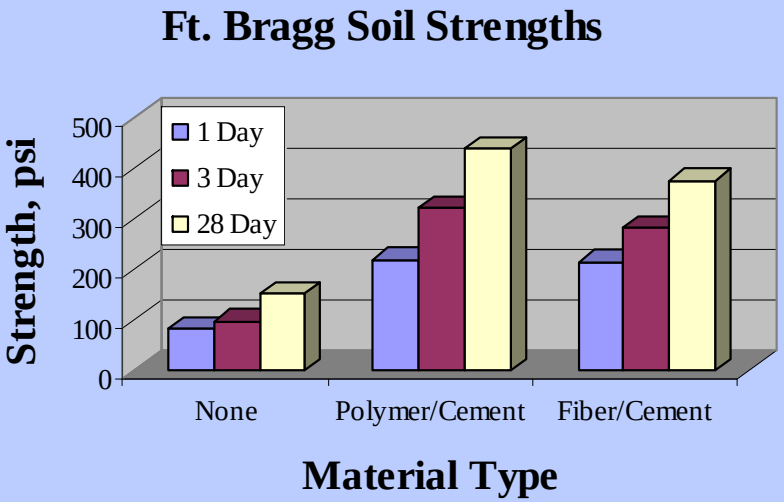
6” Clay Gravel Base

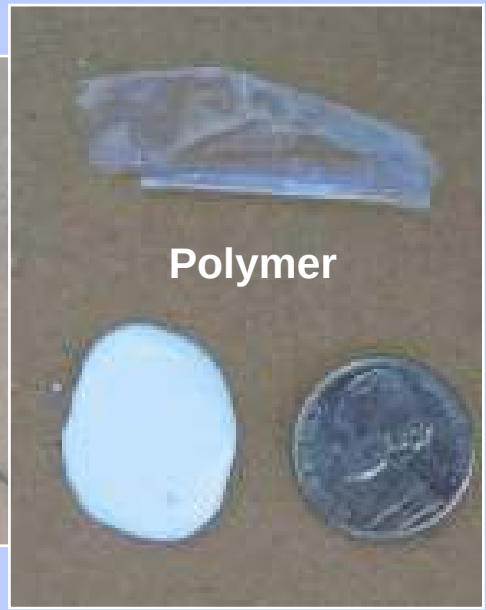
Installing pressure cells
at top of clay subgrade

C-130 Load Cart on Durabase

Ft. Bragg Demonstration - Materials

- **ACE Mat**
  - Lightweight, easy to handle
  - Easy to install
  - Fiberglass
- **Polymers and Fibers - Why?**
  - Reduced Logistics
    - Polymers and fibers weigh less than half of cement
  - Improved Performance
    - Less cracking means less FOD
  - Polymer/Cement Synergy
    - Polymer/fiber helps cement
    - Cement Helps polymer/fiber



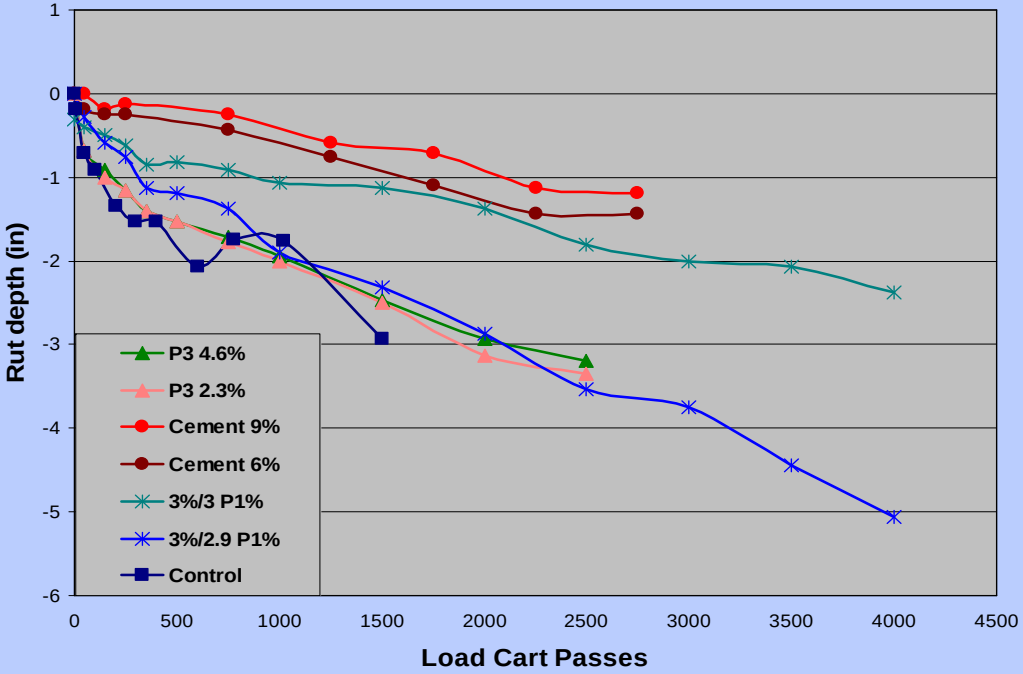


C-130 Load Testing of Stabilized Surfaces

Rut Depth with Number of C-130 Wheel Passes

ERDC HVS Test Facility

P1 – Emulsion Polymer #1
P3 – Emulsion Polymer #3



Ft. Bragg Demo Candidates – Testing

- C-130 Wheel load 30,000 lb, 750 passes
- One Day Cure
- SM Soil

Loaded C-130 Wheel on SM Soil

Cracked at edge of wheel path 5″ rut

C-130 Testing on Emulsion Polymer/Cement

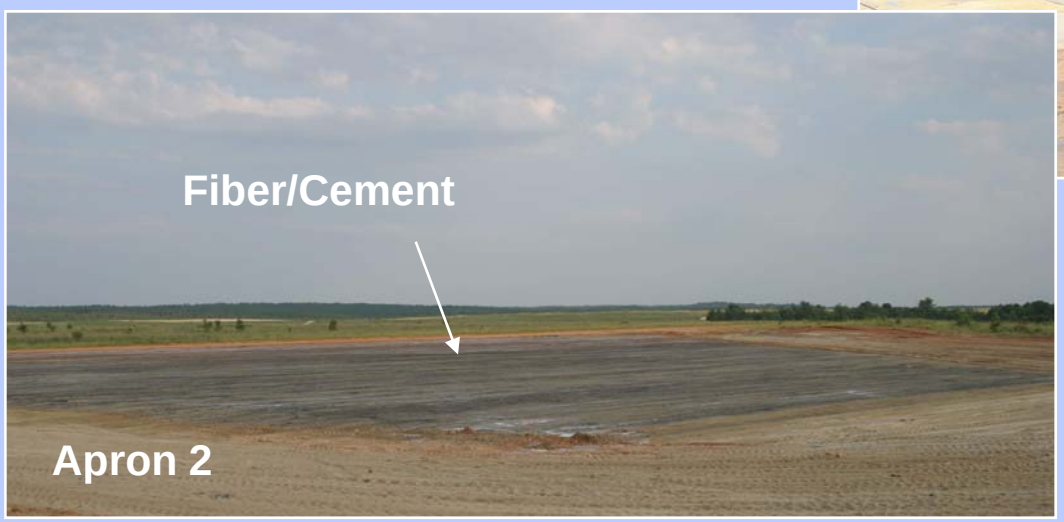
Cracked at edge of wheel path, 3″ Rut

C-130 Testing on Fiber/Cement

No cracks
½” Rut @750 passes

Ft. Bragg Demo – C-130 Parking Aprons

- **Two C-130 Parking Aprons – 40,000 sq.ft. each**
  - **Apron 1**
    - **Half ACE mat**
    - **Half polymer/cement**
  - **Apron 2**
    - **Fiber/Cement**

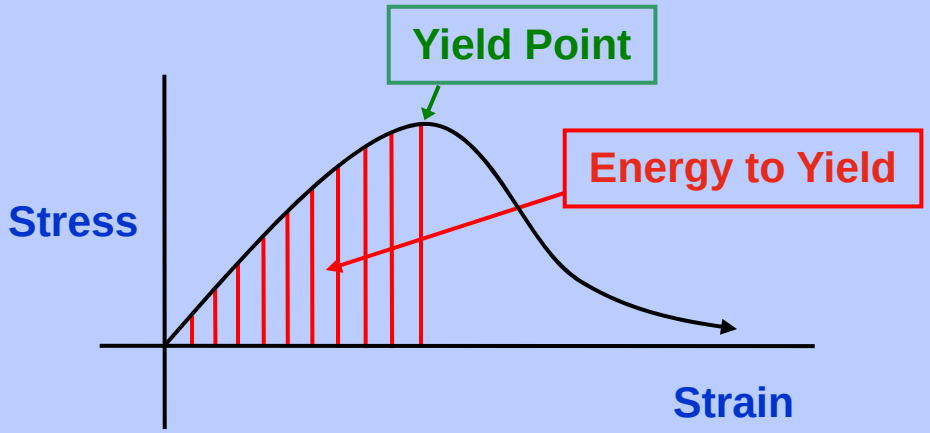


SM Soil CBR 10-15

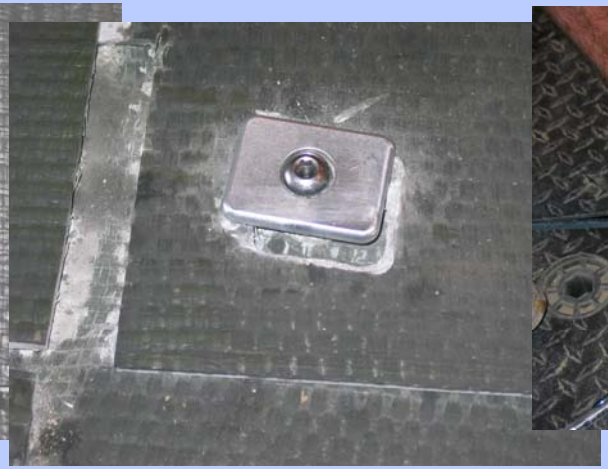
Sicily ALZ, Ft. Bragg, NC

FY05 Activities

- C-17 Load Testing – Contingency loads at 206 kips/gear
  - Commercial Mats
    - Soloco Durabase – Heavy Duty
    - Soloco Bravo – Lightweight
    - ACE mat – Lightweight
  - Stabilized Soil
    - Fiber/Cement
      - Synthetic
      - Wood/Cellulose ?
- Laboratory Testing
  - Moisture-Cure Polyurethanes
  - Different fiber types
    - Monofilament vs. fibrillated
    - Wood/cellulose
  - Improve fiber/soil/cement adhesion

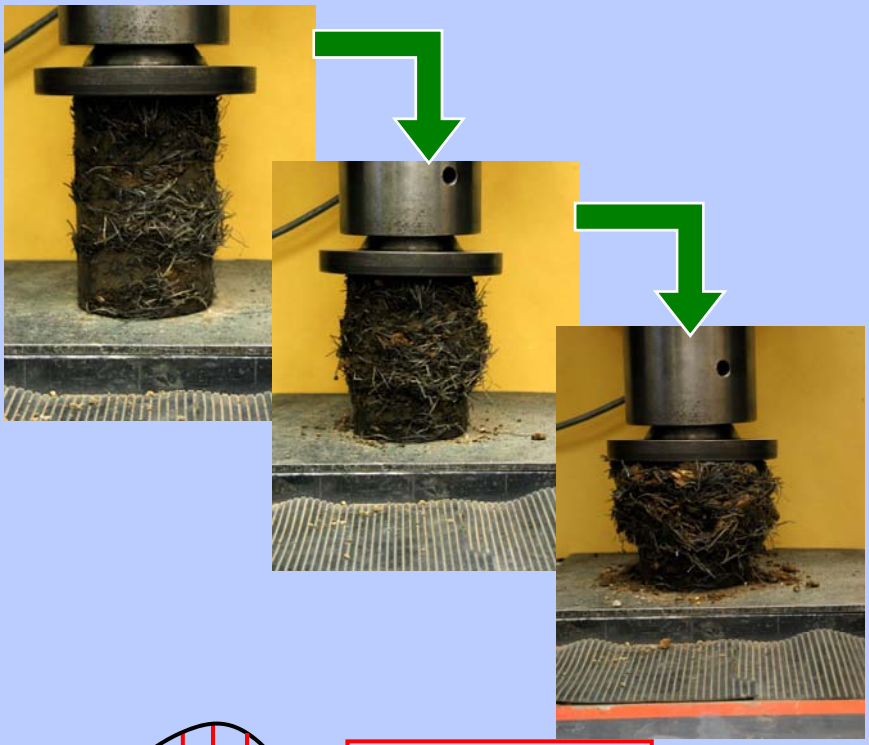


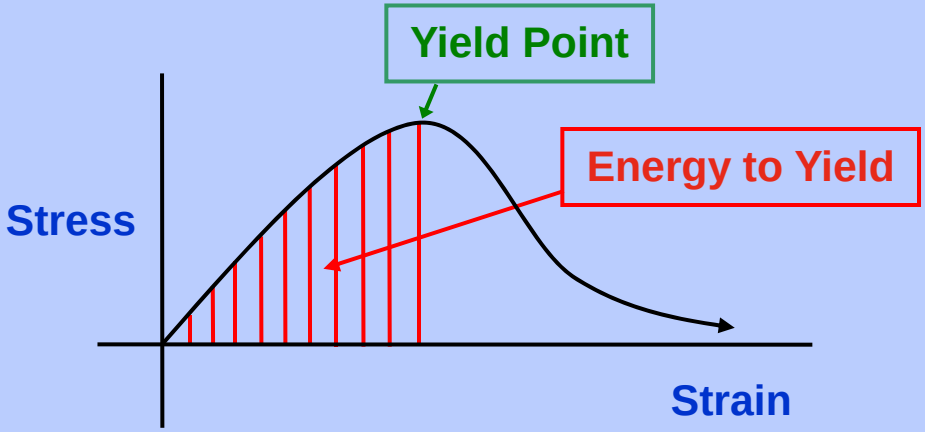
- **What have we learned so far?**
  - **Durabase is an excellent load-bearing mat**
    - **Logistically unwieldy**
    - **Heat resistance?**
  - **Bravo mat suffered mechanical failure**
  - **ACE Mat is an excellent lightweight mat for medium strength (CBR >8) soils**
    - **1000 passes of C-17 at contingency operating weight (206 kips) with minimal damage over CBR 8-10 SM soil**
    - **Needs proper anchoring for wind loads**

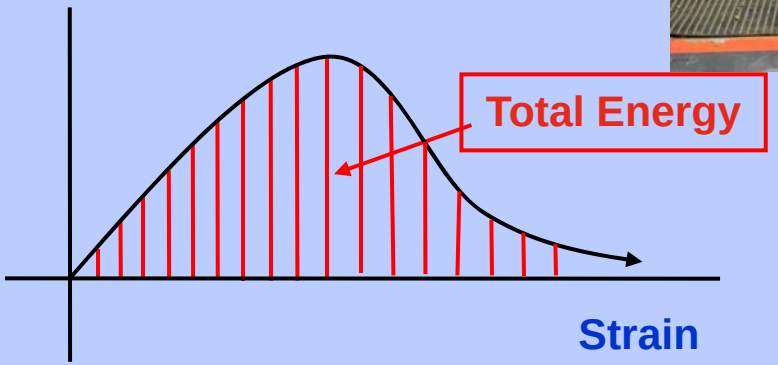


Soil Stabilization

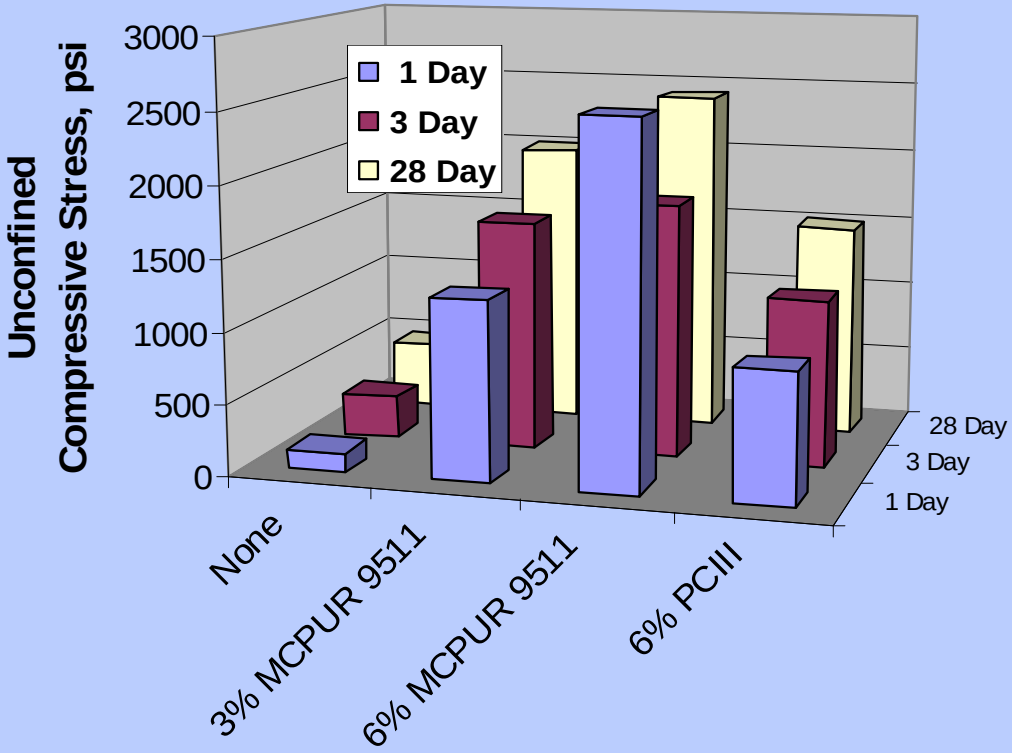
- **Laboratory Testing of Soil Stabilizers**
  - Moisture-Cure Polyurethanes
  - Different fiber types
    - Monofilament vs. fibrillated
    - Wood/cellulose
  - Improve fiber/soil/cement adhesion



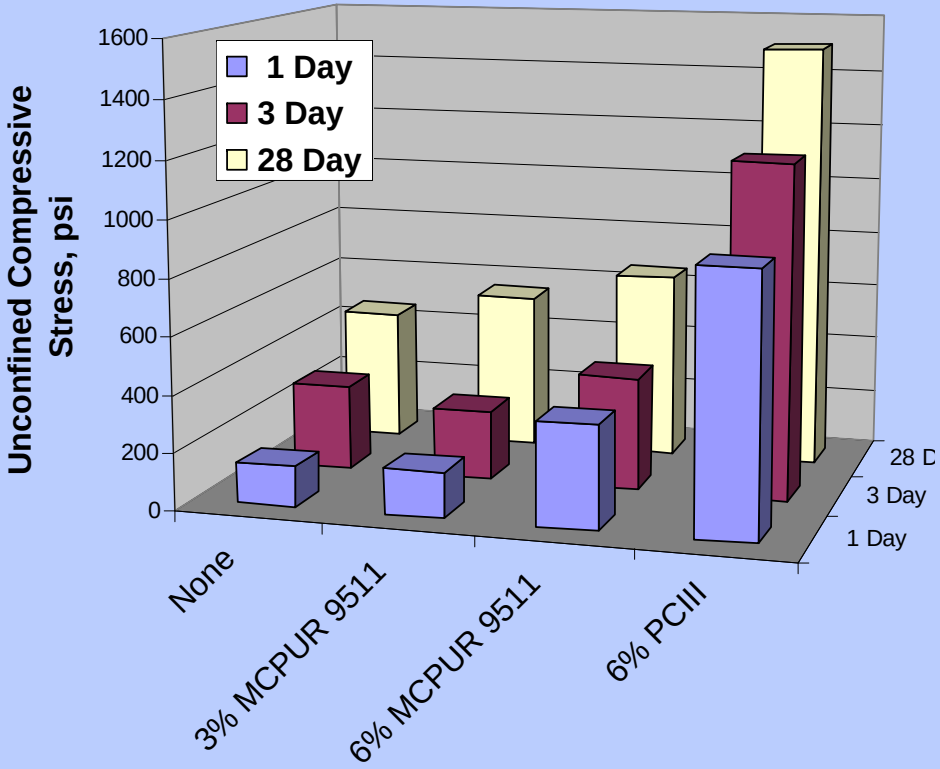




Moisture Cure Polyurethanes - MCPUR

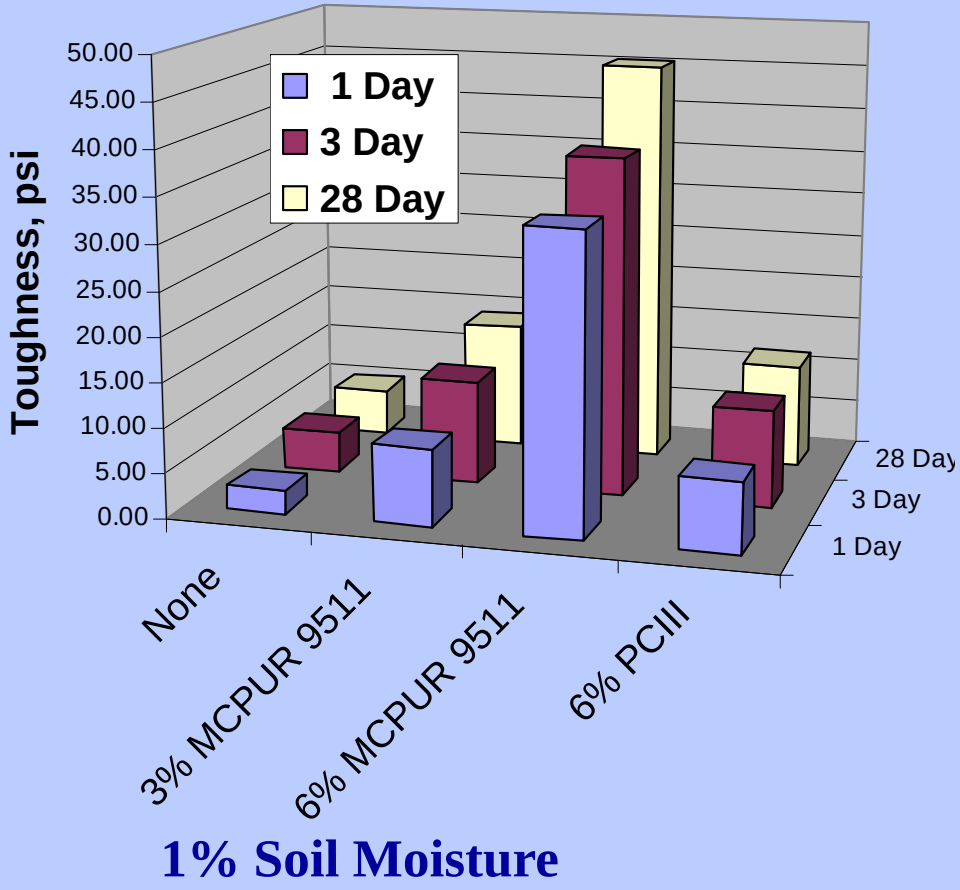


1% Soil Moisture



5% Soil Moisture

Moisture Cure Polyurethanes - MCPUR



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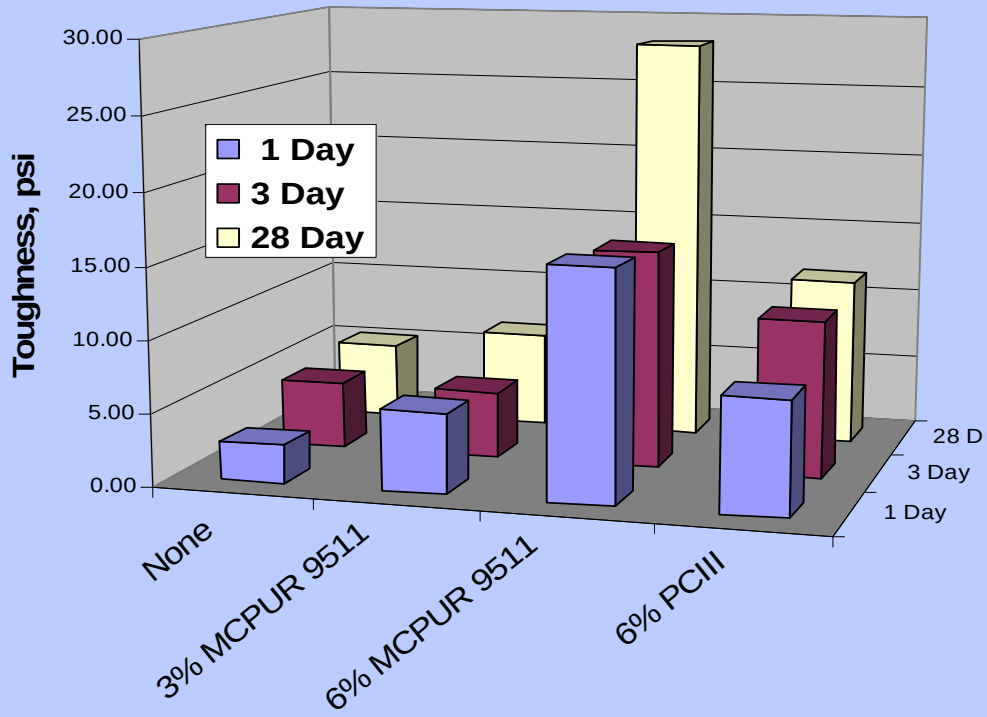
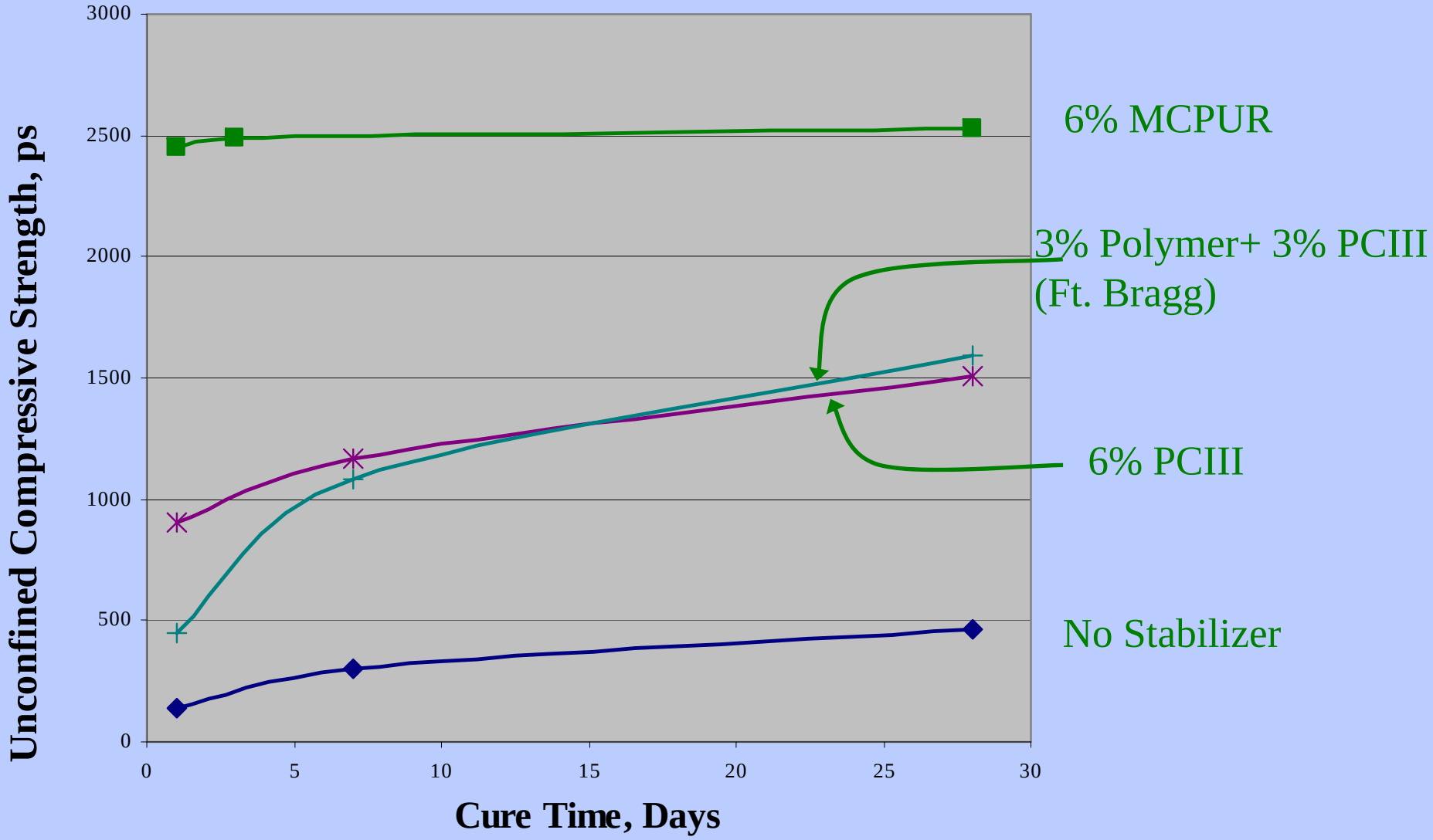
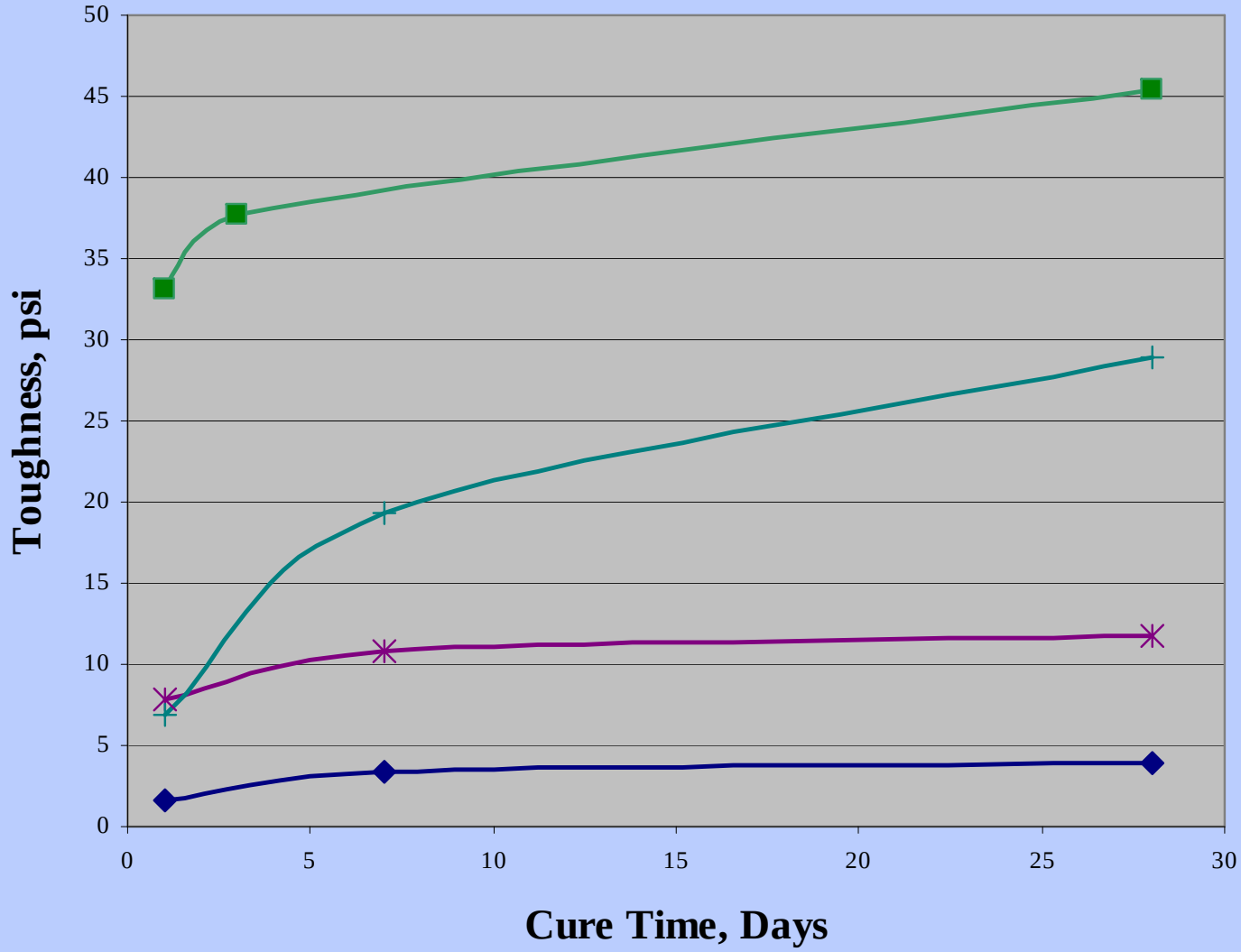


5% Soil Moisture

MCPUR Cure Time - UCS



MCPUR Cure Time - Toughness



6% MCPUR

3% Polymer
+ 3% PCIII

5% PCIII

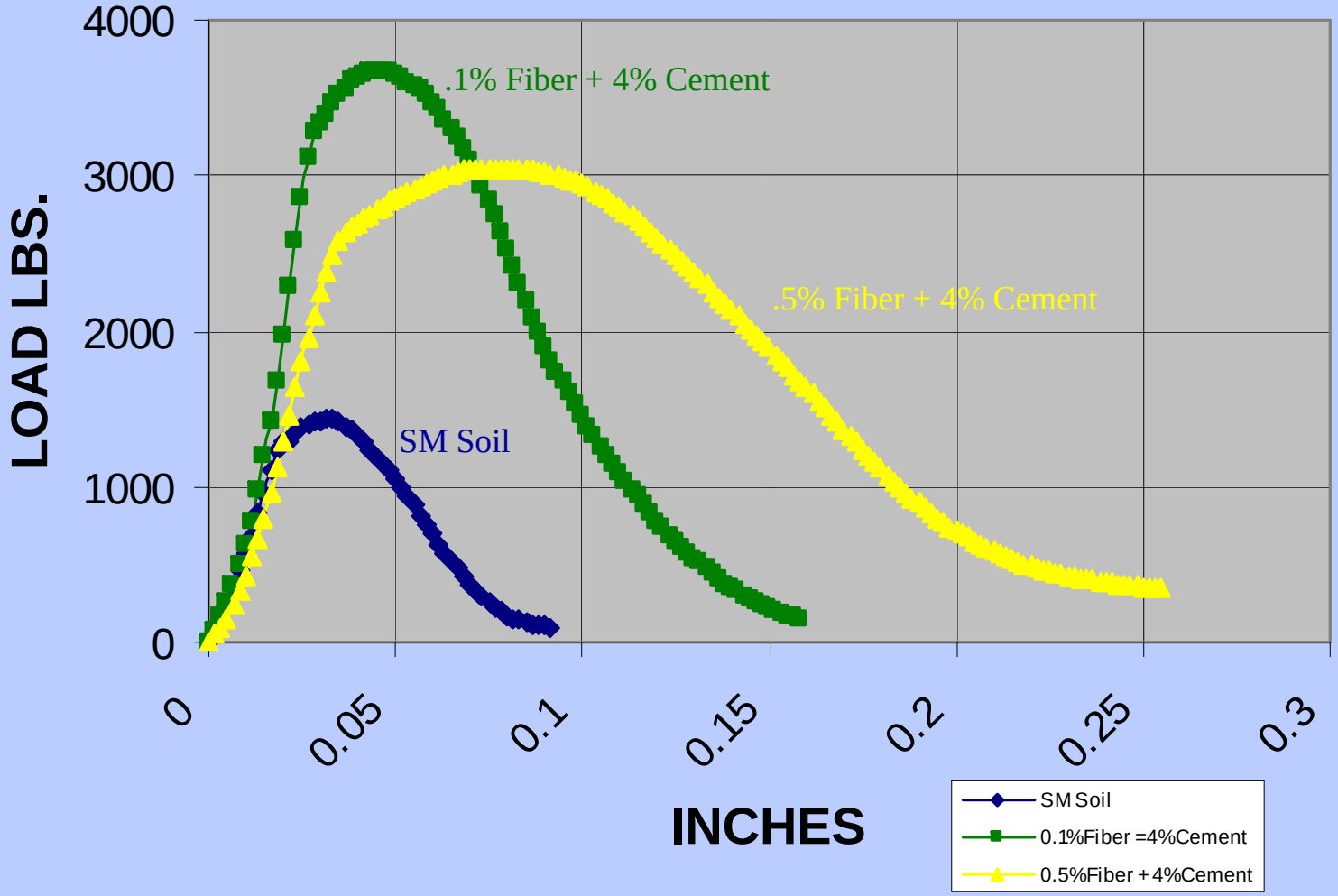
No Stabilizer

So Why not MCPUR?

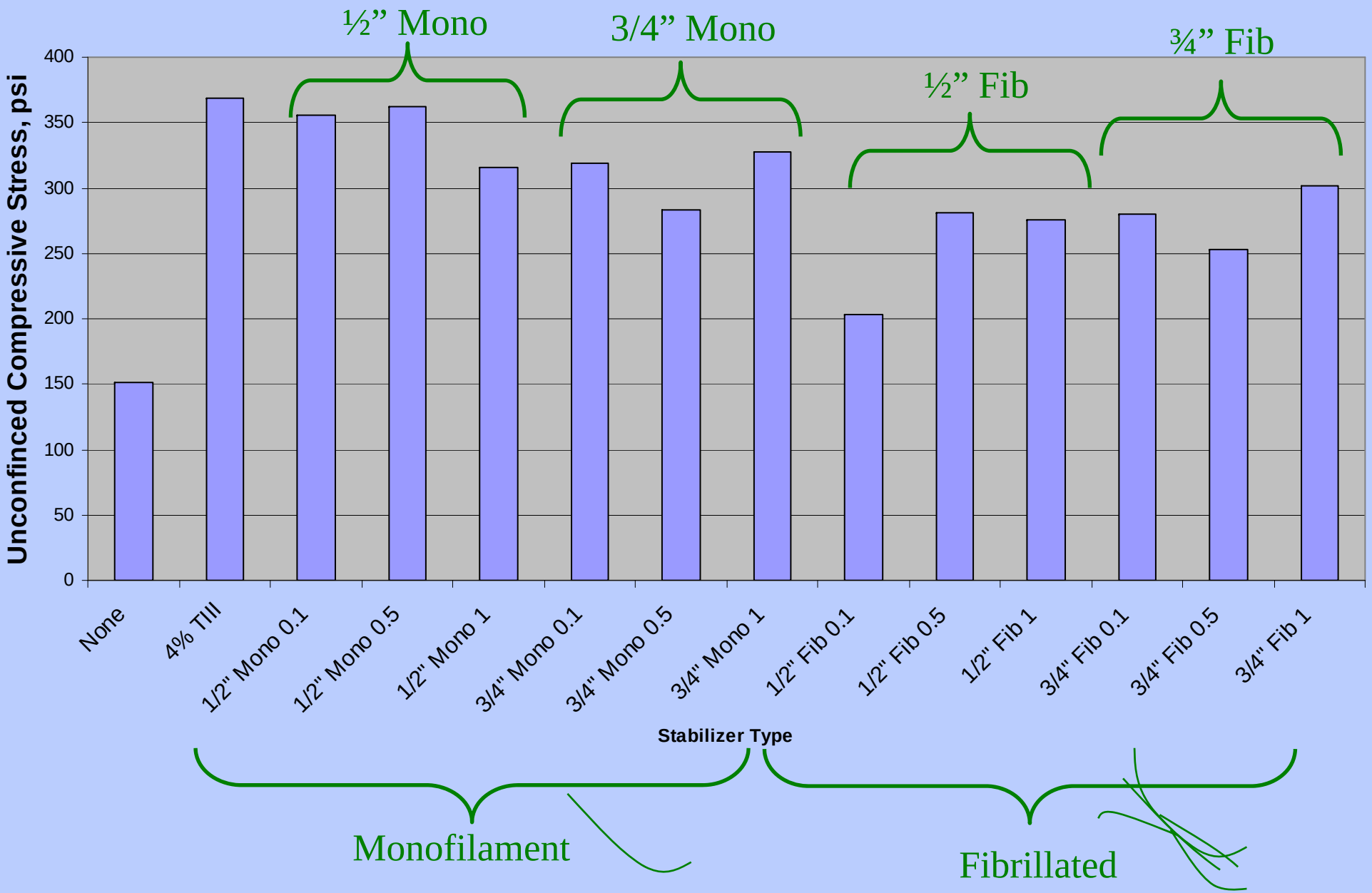
- **Advantages**
  - **Super stress and strain properties**
    - Would be great with added fibers
  - **Disadvantages**
    - Hard to construct with
      - Viscosity like honey
      - Sticks to equipment
      - Difficult to clean
    - Very expensive
    - Poor shelf life
    - Hazardous

Effects of Cement and Fibers on Soil

- **Stress/Strain Response – ¾" Fibers**



Effects of Fiber Type and Concentration



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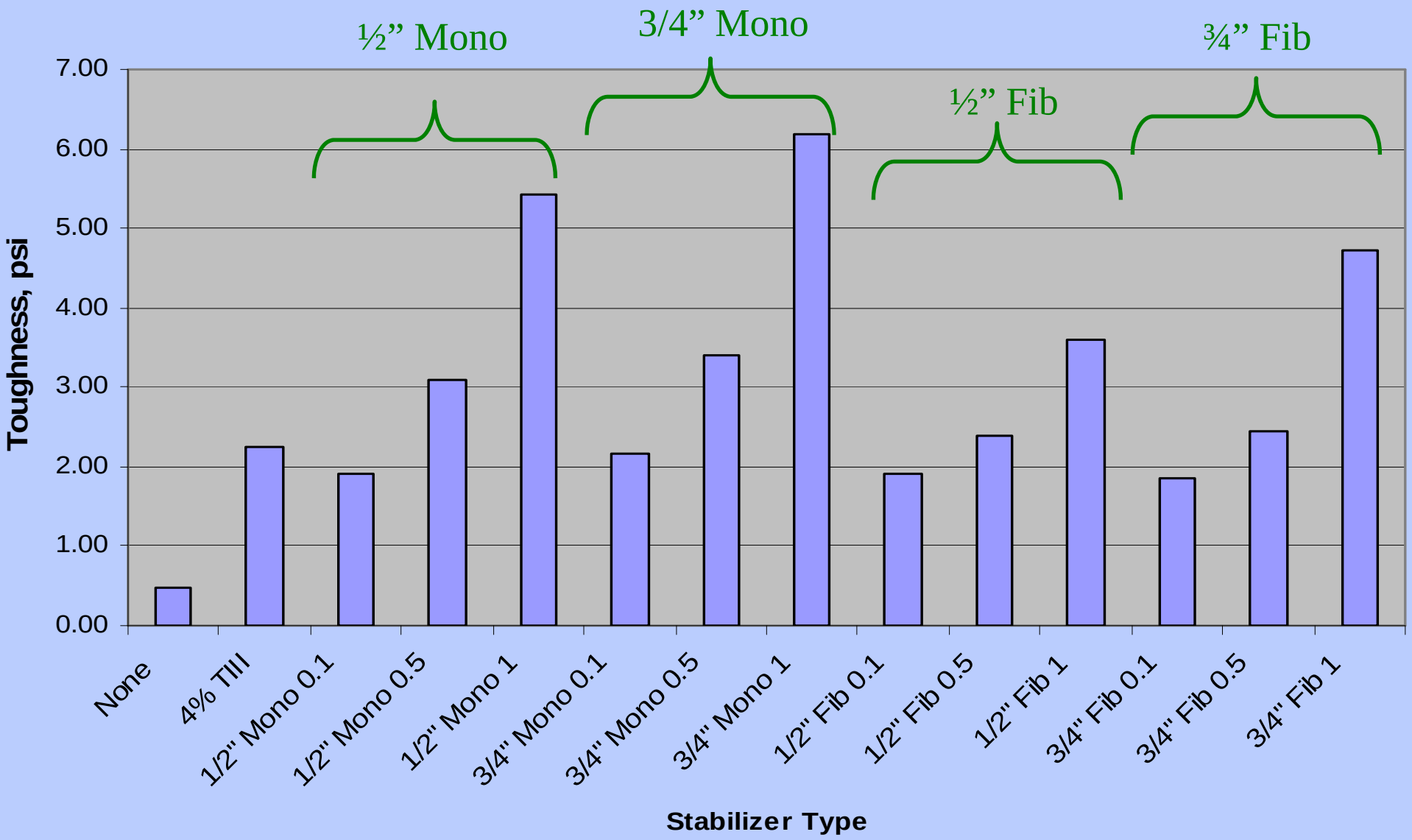

Soil Stabilization

- **What have we learned so far?**
  - Cement is hard to beat - Economical, ubiquitos, easy to use
    - FOD nightmare when it fails
  - Fibers are excellent in blends with binders such as polymers and cements
    - Fibers reduce cracking – less FOD
    - Too long and fibers are hard to construct with
  - Emulsion polymers are easy to use
    - Great for weatherproofing, dustproofing surfaces
    - Don’t perform as well as fibers in blends with cement
    - Slow to cure without ‘help’ (cement)

Soil Stabilization

- **What have we learned so far?**
  - **Fibers**
    - **Improving adhesion of fiber to cement/soil is beneficial- ongoing research**
  - **Curing Polymers - Epoxies/polyurethanes**
    - **Single Component Moisture Cure Polyurethanes (MCPUR)**
      - **Great Properties**
      - **Hard to control, construct with**
    - **Two-Component Polyurethanes/Epoxies**
      - **Great Properties**
      - **Strict mixing requirements – special equipment needed**
      - **Can be controlled better than MCPUR**

FY06-07 Activities

- **FY06 – C-17 Loads**
  - **Field Studies**
    - **Soil Stabilization**
      - **SM Soil 6” Depth, CBR 8-10**
        - **Synthetic Fiber/Cement Blends**
        - **Wood/Cellulose/Cement Blends**
      - **Clay Soil**
        - **Candidate materials will be based on laboratory studies**
      - **Maintenance and repair will be accomplished during field studies**
    - **Mat testing over Clays**
  - **Laboratory Studies**
      - **Stabilization of Clay Soil**
        - **Cement, lime, fibers, ionic stabilizers**
- **FY07 – C-17 Demonstration**

Questions ?