



Joint Rapid Airfield Construction

Rapid Stabilization for Airfield Construction

Kent Newman, PhD

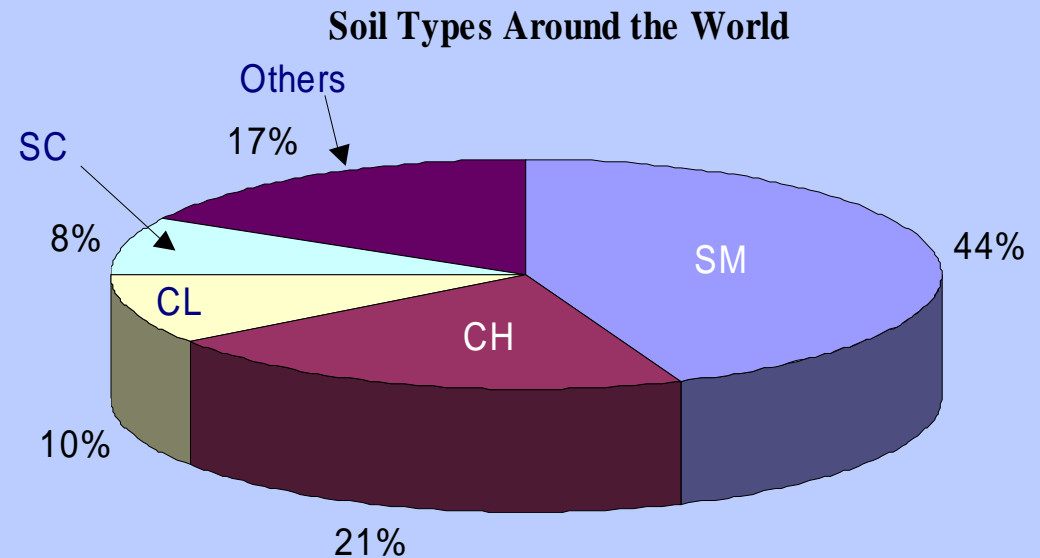
Airfields and Pavements Branch

Geotechnical and Structures Laboratory

Engineer Research and Development Center

- **Objective**

- To implement rapid stabilization commercial-off-the-shelf technologies for contingency airfield construction



- **Scope**

- To employ mats, soil stabilizers, fibers, geotextiles, etc... for rapidly constructing contingency airfields or for enhancing the performance of existing unsurfaced airfields

- **What Materials Can be Used to Rapidly Construct Airfields in Austere Environments?**

→ **How...**

- ▶ *much material has to be delivered to the site?*
- ▶ *much effort/equipment is needed to construct it?*
- ▶ *soon can we put aircraft on the surface?*
- ▶ *many (and at what loads) aircraft operations are possible?*
- ▶ *much repair (and how it is done) is necessary?*



Rapid Stabilization Pillar 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 | | | | | | |
| 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 | | | | | | |



- **Development of Stabilizers for Accelerated Curing**
- **Demonstration of Advanced Stabilizer Technologies (C-130)**
- **Rapid MOG Enhancement Technologies**
- **Stabilization of Thawing Soils**
- **Stabilization of Thawing Soils Demonstration**

Development of Stabilizers for Accelerated Curing

Kent Newman, PhD

FY02 - \$250K

FY03 - \$250K

- **Development of Stabilizers for Accelerated Curing**

- **Objective**

- ▶ *Provide a rapid-curing COTS soil stabilization technology that is readily constructable with low logistics, will withstand C-130 wheel loads, provide low maintenance and low FOD potential, and is readily repairable.*

- **Scope**

- ▶ *Reduce weight of materials by up to 50% and cure times by up to 96% compared to 11% cement/soil by weight and 28 days cure time.*
- ▶ *Ultimate targets are 5-6% stabilizer and 1 day cure times. Interim targets are 6-9% stabilizer and 3-7 day cure times.*

- **Product**

- ▶ *Guidelines for non-traditional stabilizers and accelerator use for rapid stabilization of soils for contingency airfield construction*

- **Approach**

- Use unconfined compression strength to screen a range of COTS technology for several soil types beginning with SM, silty sand and moving to CH and CL soils.
- Utilize blends of additives for improved stabilized soil durability and improved cure times, i.e. Type I, Type III cements with emulsion polymers and admixtures
- Focus on promising candidates and conduct more elaborate testing to estimate field durability
- Determine best potential for which class of soil stabilizer works best for a given soil type.

- Numerous commercial stabilizers tested with SM, CH, CL soils
 - ▶ *Acids*
 - ▶ *Lignosulfonates*
 - ▶ *Lime*
 - ▶ *Cement*
 - ▶ *Polymers*
 - ▶ *Tree resins*
 - ▶ *Fibers*
- This work provides an excellent base for judging which stabilizers offer benefits for a particular soil type

- **Strategy for Silty Sand Stabilization**

- **Not much opportunity for chemical reactions as with clay or organic components**

- ▶ *Varies with soil type*

- **Must utilize cementing agents that bind soil particles**

- ▶ *Portland cements – dry mixing*

- ▶ *Best vehicle for efficient mixing are liquid emulsions*

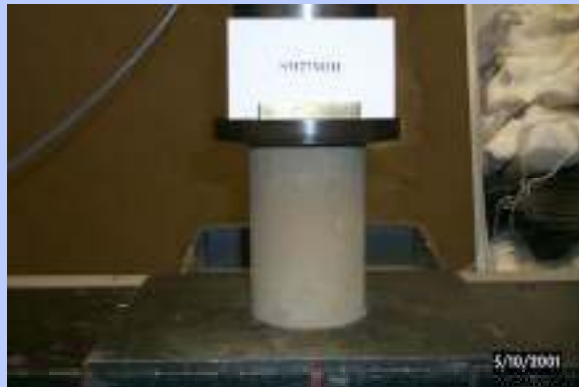
- **Polymers – vinyl acetates, acrylics**

- **Asphalts**

- **Tree Resins**

- **Progress**

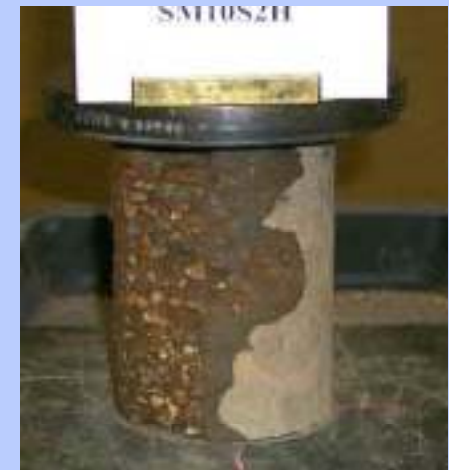
- Several soil improvement agents that represent a range of stabilizer types have been tested at concentrations ranging from 0-5% for a SM soil. These agents were tested under dry and wet conditions at cure times of 1, 7, and 28 days.



DRY UCS Test

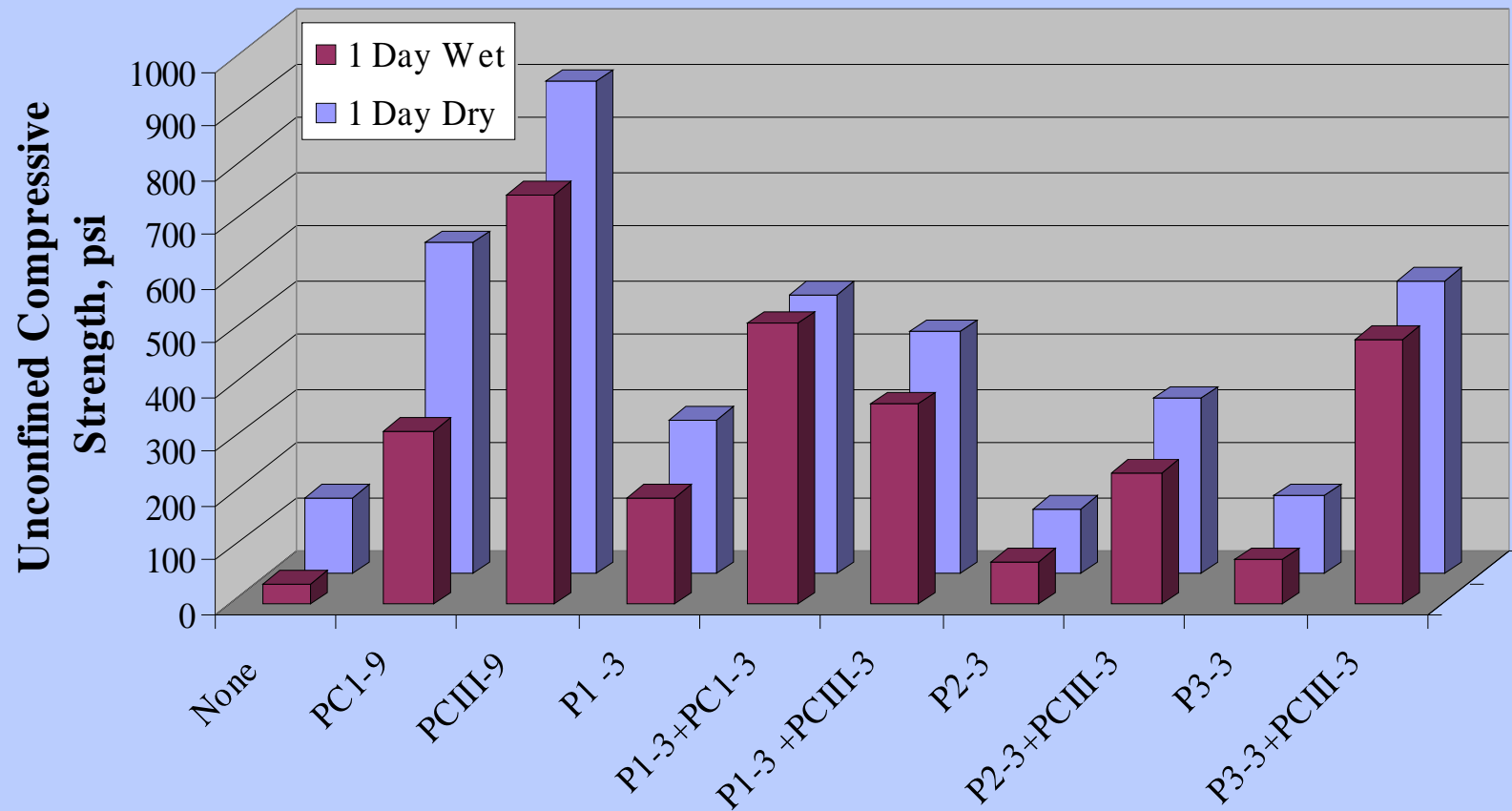


Soak Sample



Wet UCS Test

Unconfined Compressive Strength Stabilized Silty Sand – One Day Cure



- Progress

- Based on previous ERDC studies, the scope was narrowed to a few specific products. Testing was conducted at 1, 7, and 28 days.

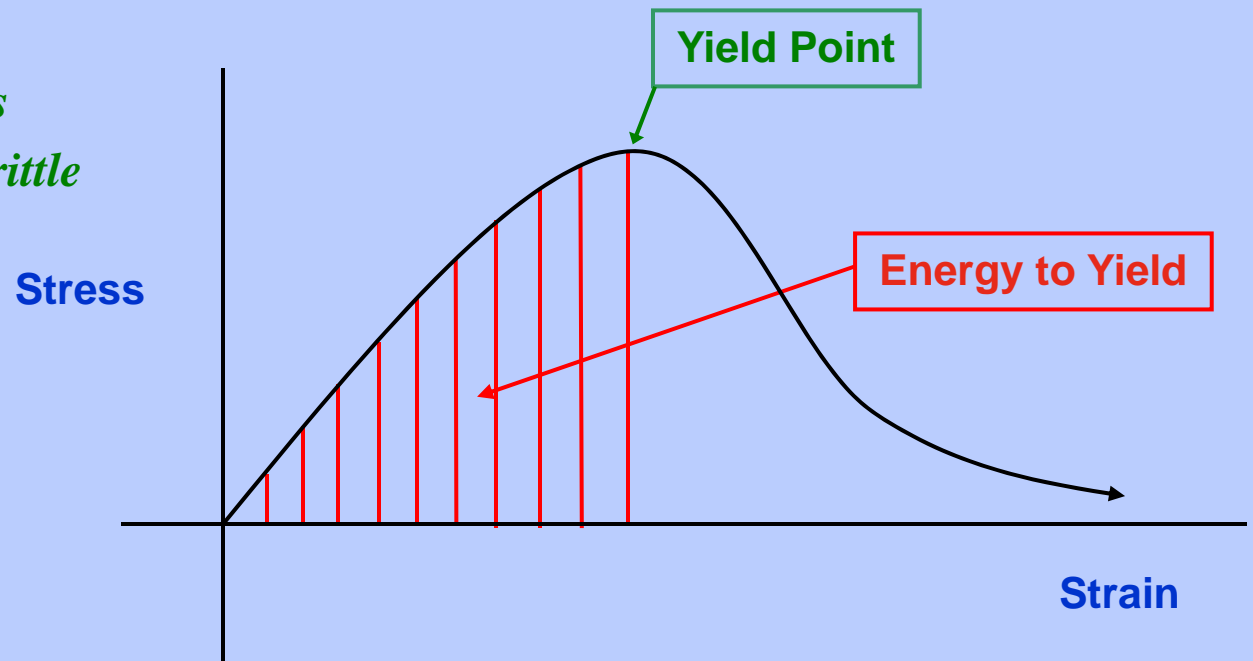
- Results reevaluated in terms of Toughness

- UCS does not capture property improvements due to polymers

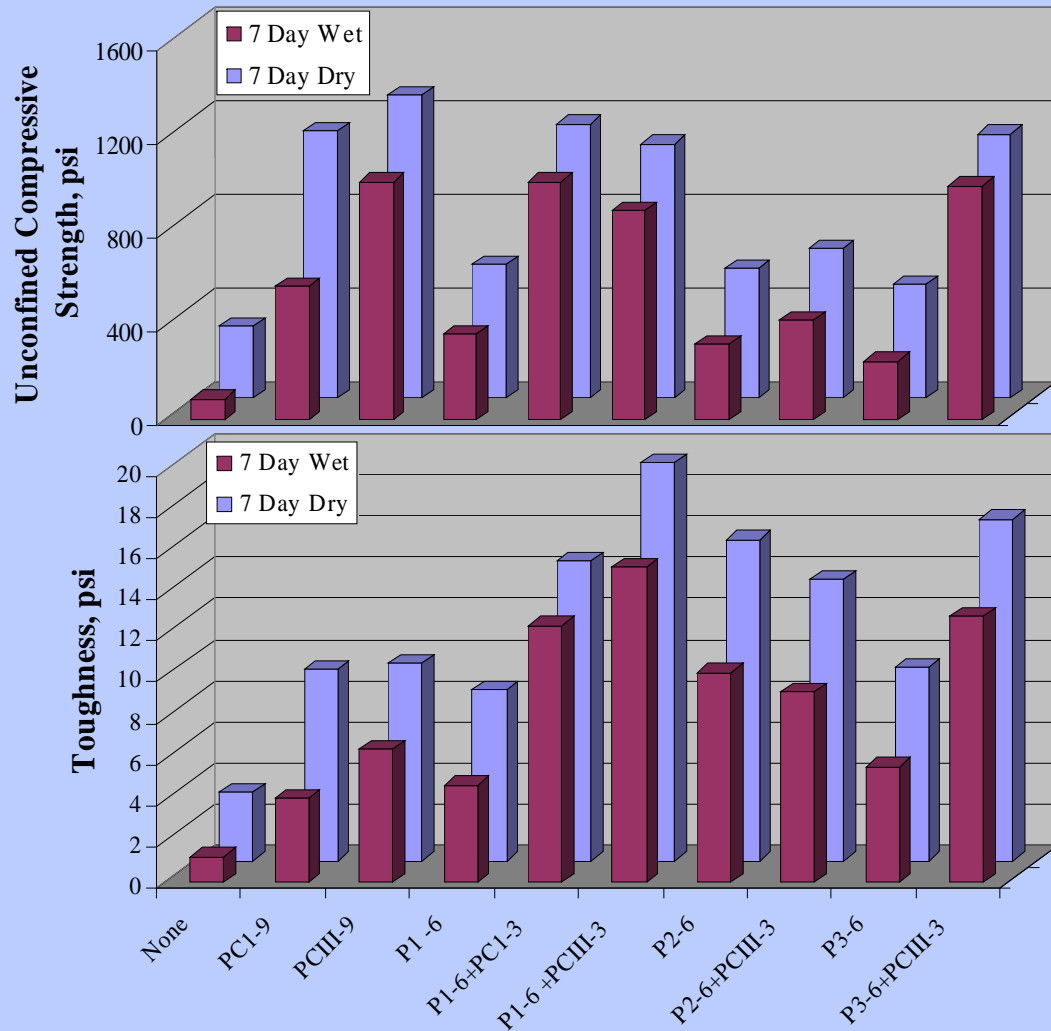
- ▶ *Max UCS for polymers occurs at higher strains*
- ▶ *Ductile Failures, not brittle*

- Toughness

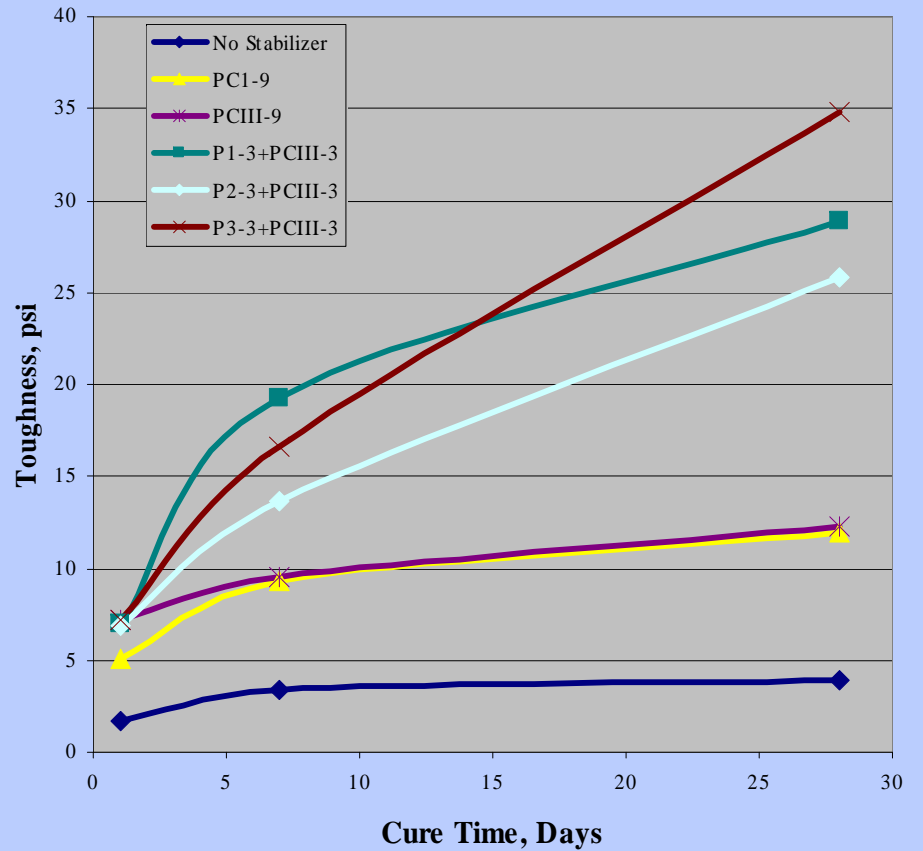
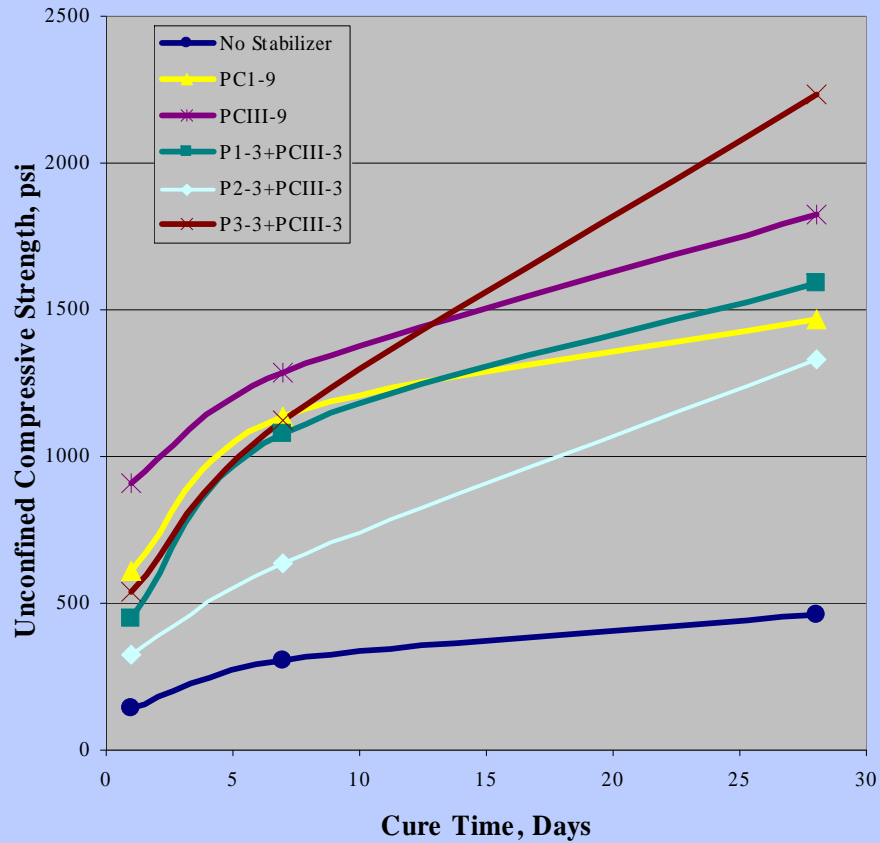
- ▶ Energy at yield
Volume
- ▶ *Energy at yield is area under stress strain at peak load*



Toughness to Yield - Stabilized Silty Sand - 7 days Cure



Cure Times



- **Conclusions to Date**

- **Polymers yield similar compressive strengths at lower contents as portland cement**
 - ▶ *Cure times similar to cement*
- **Polymers greatly improve strain to failure of silty sand**
 - ▶ *Costly !!!*
- **Cure times still need some improvement**
 - ▶ *Where available use Type III cements*
 - ▶ *Use of Type I accelerators*
- **Durability suffers at stabilizer concentrations below 9%**
 - ▶ *Sacrifice durability to reduce stabilizer amounts*
- **Ultimate targets of 4-5% total weight of stabilizers and 3-day cure times are achievable**
 - ▶ *Durability will be an issue*

- **Future Work**

- Investigate use of admixtures with Type I cement/polymer combinations
 - ▶ *Increase early strength*
 - ▶ *Improve durability*
- Use of fibers (i.e. polypropylene)
- Broaden scope of durability testing



Rapid Stabilization Pillar

Demonstration of Advanced Stabilizer Technologies (C-130)



Demonstration of Advanced Stabilizer Technologies (C-130 Demo)

- **Objective**

- To verify materials, design, and construction of stabilized soils for supporting C-130 operations

- **Scope**

- To construct test sections for trafficking under C-130 wheels and loads
- To conduct/support field demonstrations of stabilization technology

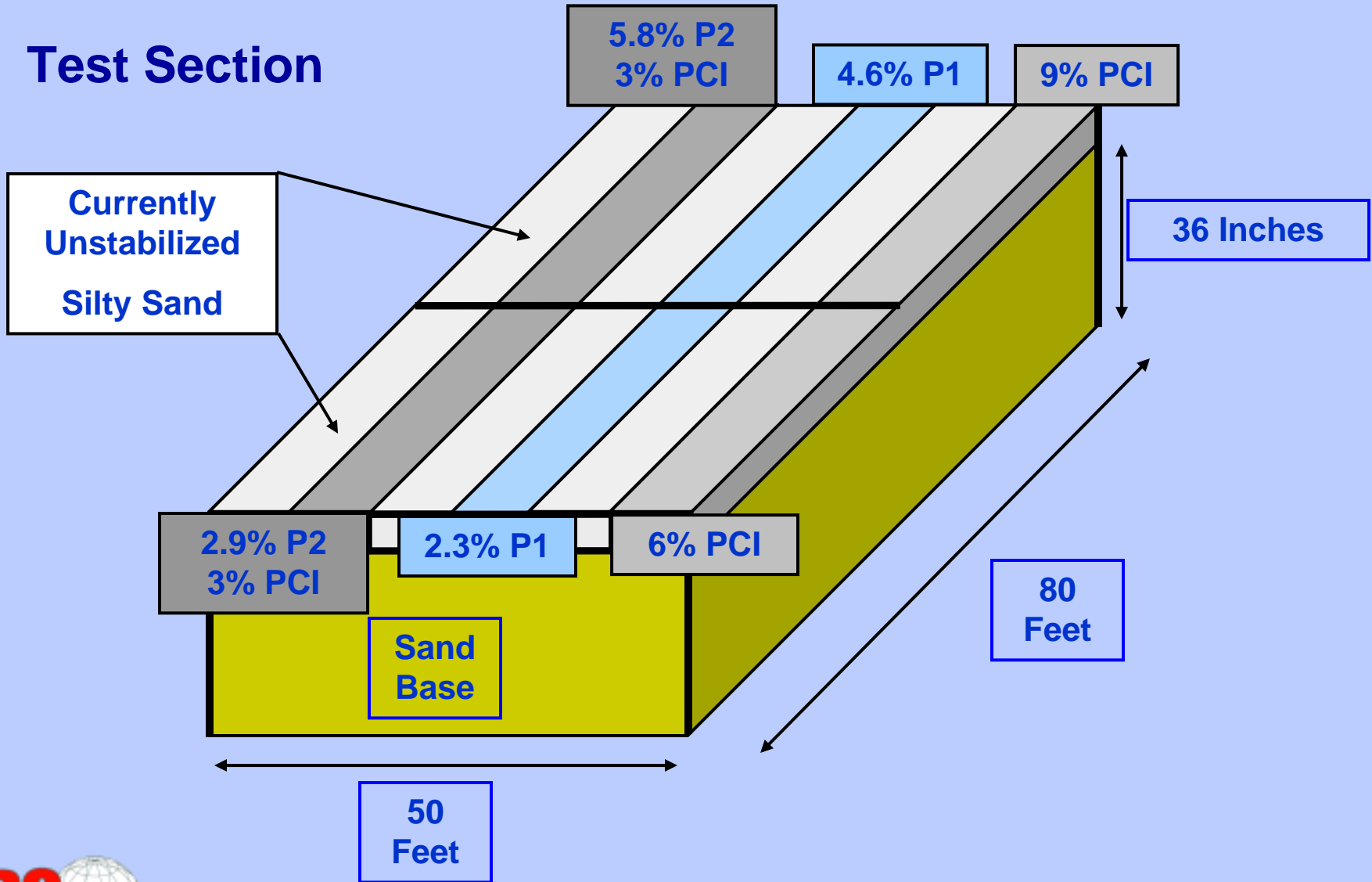
- **Product**

- Criteria for achieving rapid stabilization of soils for C-130 contingency operations

- **Approach**

- **Construct test sections for trafficking under C-130 wheels loads.**
 - ▶ *30 kip – 95 psi tire pressure*
 - ▶ *up to 5000 repetitions*
- **Conduct/support field demonstrations of stabilization technology**
 - ▶ *Demonstrate advanced stabilization technology as part of a warfighter exercise to construct/upgrade a contingency airfield*
 - ▶ *FY04 Ft. Bragg Demo at Sicily*

- **Test Section**



Construction – Silty Sand Surface

Tilled Before Stabilizing



Added the Stabilizer



Tilled Again (2 passes)

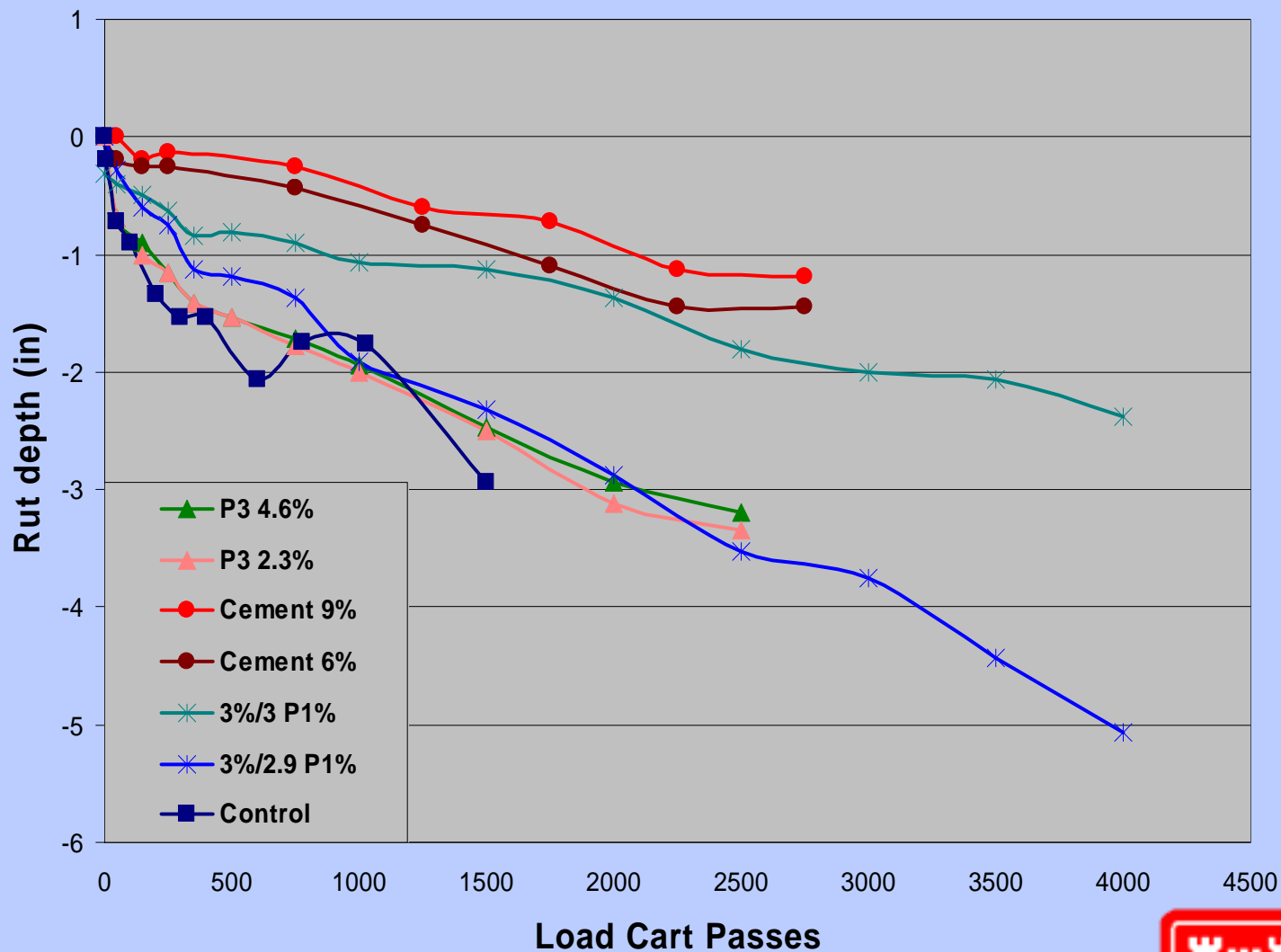


Wait 28 days, Add Traffic



Compacted to 95% Proctor

Rut Depth with Number of C-130 Wheel Passes



● Conclusions

- Portland cement is hard to beat – low cost, good performer
 - ▶ *Durability of stabilized structures may suffer at low PC contents*
- Polymers improve soil properties but are expensive
 - ▶ *Is benefit worth the cost?*
- Combinations of polymers and cement work well - synergism
 - ▶ *Polymers reduce brittleness of cement*
 - ▶ *Cement improves cure times of polymers*
- Stabilizer performance is adequate but cure times must be improved
 - ▶ *Type III cements can be used if available*
 - ▶ *Type I admixtures are being explored to speed cure*

- **Future Work**

- **Use of Type III cement/polymer combinations**
- **Use of admixtures with Type I cement/polymer combinations**
- **Effects of simulated rainfall on test section performance**
 - ▶ *Durability*