Stabilization of Silty-Sand with Nontraditional Additives

Rosa L. Santoni
Jeb S. Tingle
Steve L. Webster

Research Civil Engineers

Stabilization of SM Sands with Nontraditional Additives

Objectives

- Screen off-the-shelf nontraditional stabilizers
- Determine the benefits for SM soils

Approach

- Develop knowledge base on stabilizers
- Laboratory investigation
- Performance capabilities and guidance criteria

Stabilization of SM Sands with Nontraditional Additives

Categories

- **Nontraditional Stabilizers**
  - Acids
  - Enzymes
  - Lignosulfonates
  - Polymers
  - Petroleum Emulsions
  - Tree Resin
- **Traditional Stabilizers**
  - Cement
  - Asphalt
  - Lime

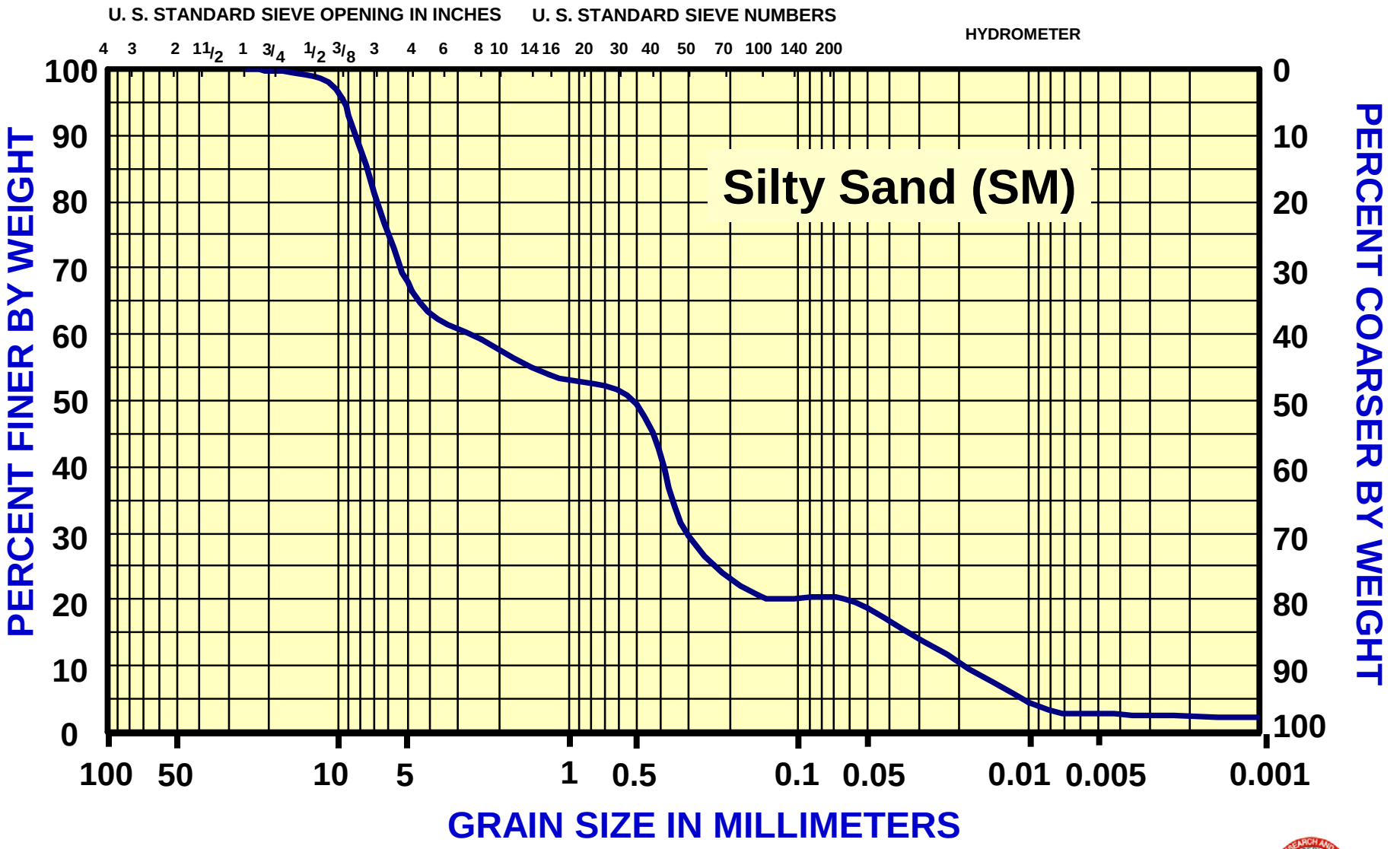
Stabilization of SM Sands with Nontraditional Additives

Worldwide Soil Types

Soil Type	Percent
SM	44
CL	21
CH	10
SC	8

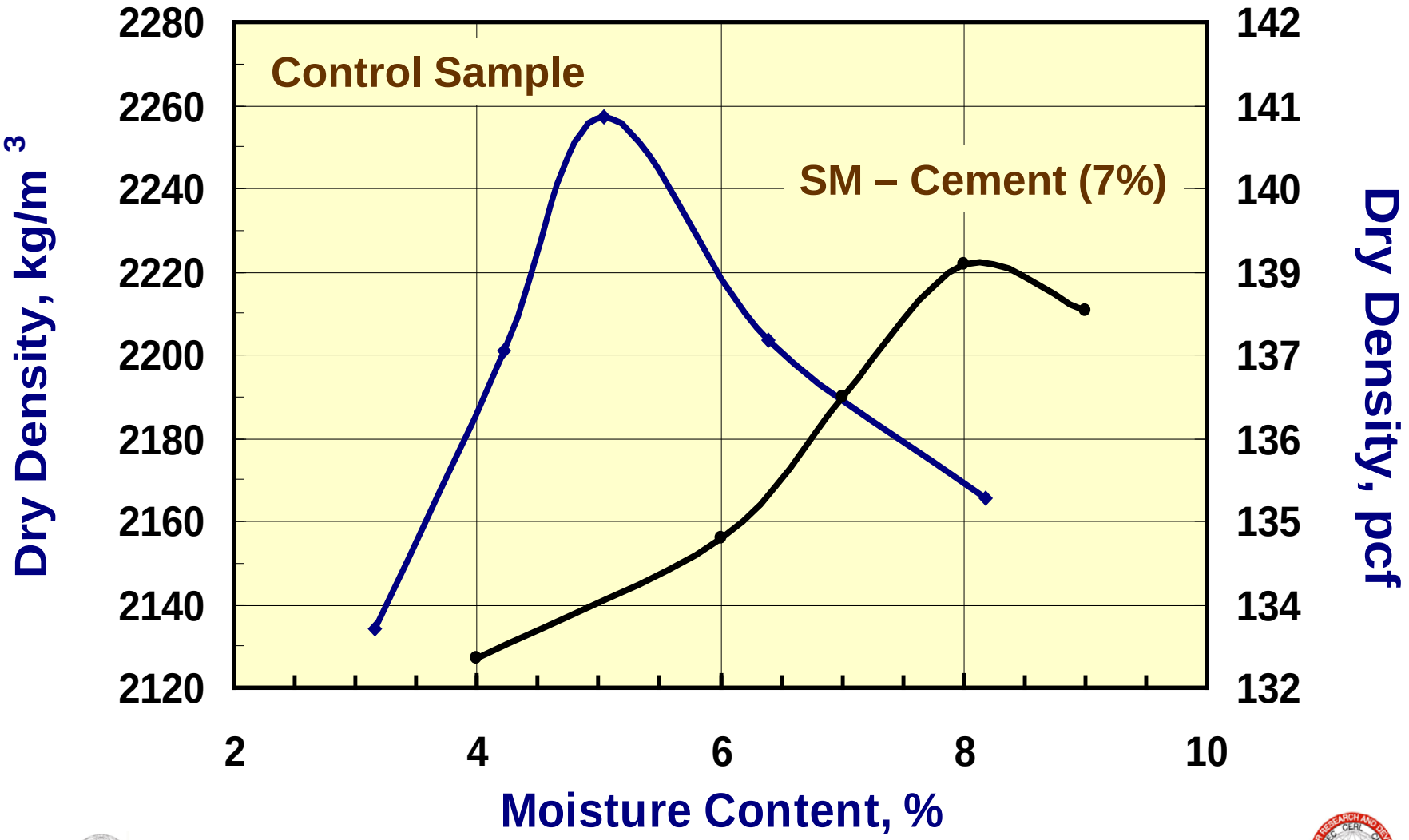
Stabilization of SM Sands with Nontraditional Additives

Particle Distribution



Stabilization of SM Sands with Nontraditional Additives

Compaction Curve



Stabilization of SM Sands with Nontraditional Additives

Experiment Design

STABILIZER	Reinforcement Mechanism	LOW	MEDIUM	HIGH
Control	None	X		
Cement	Mechanical/Chemical	X	X	X
Asphalt	Mechanical	X	X	X
Lime	Chemical	X	X	
Acid 1	Chemical	X		
Lignosulfonate 1	Mechanical	X	X	X
Lignosulfonate 2	Mechanical	X		
Enzyme 1	Chemical	X		
Enzyme 2	Chemical	X		
Enzyme 3	Chemical	X		
Enzyme 4	Chemical	X		
Polymer 1	Mechanical	X	X	X
Polymer 2	Mechanical	X	X	X
Polymer 3	Mechanical	X	X	X
Petroleum Emulsion 1	Mechanical	X	X	X
Tree Resin 1	Mechanical	X	X	X

Stabilization of SM Sands with Nontraditional Additives

Specimen Preparation

SM Soil Preparation

Additive Preparation

Soil-Additive Mixing

Sample Molding

Sample Compaction

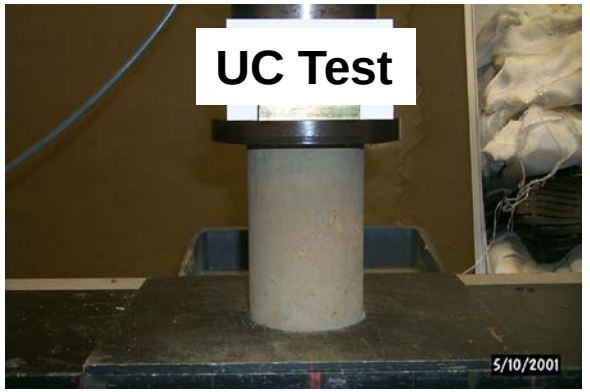
Sample Curing

Stabilization of SM Sands with Nontraditional Additives

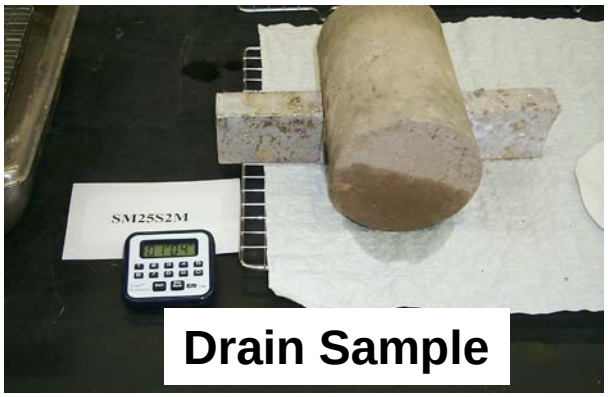
Laboratory Test

UC TEST

DRY TEST

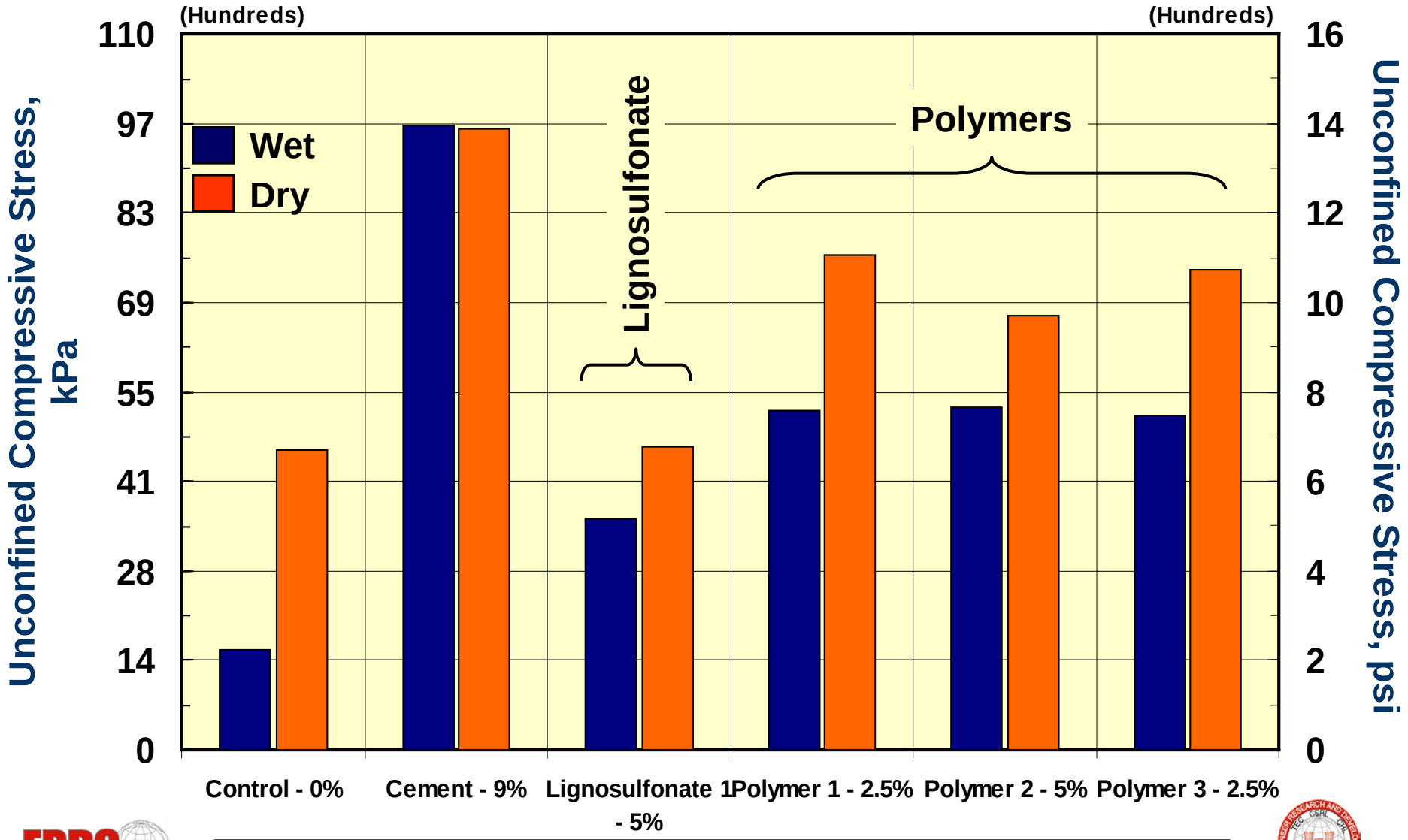


WET TEST



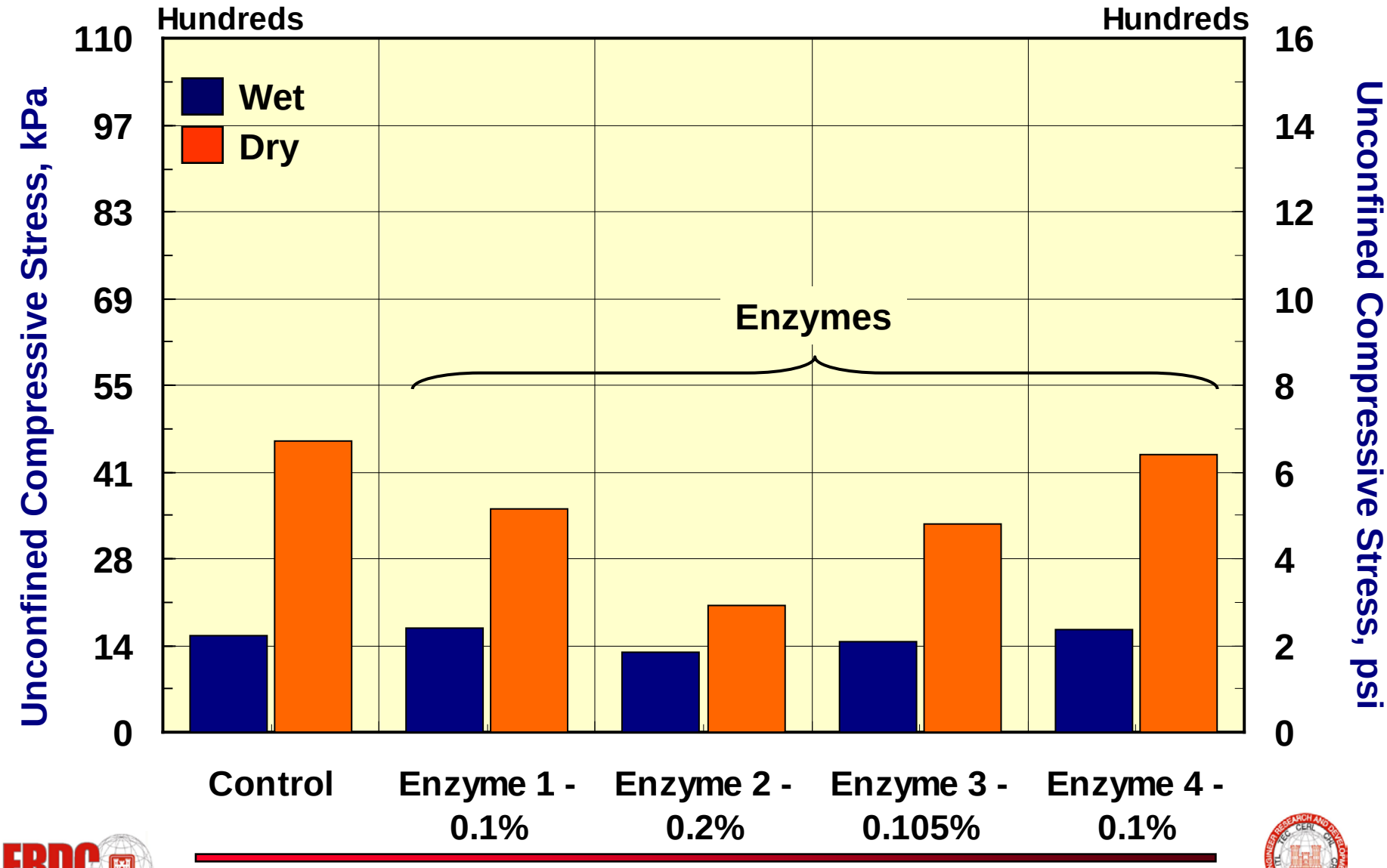
Stabilization of SM Sands with Nontraditional Additives

Effect of Stabilizer Type



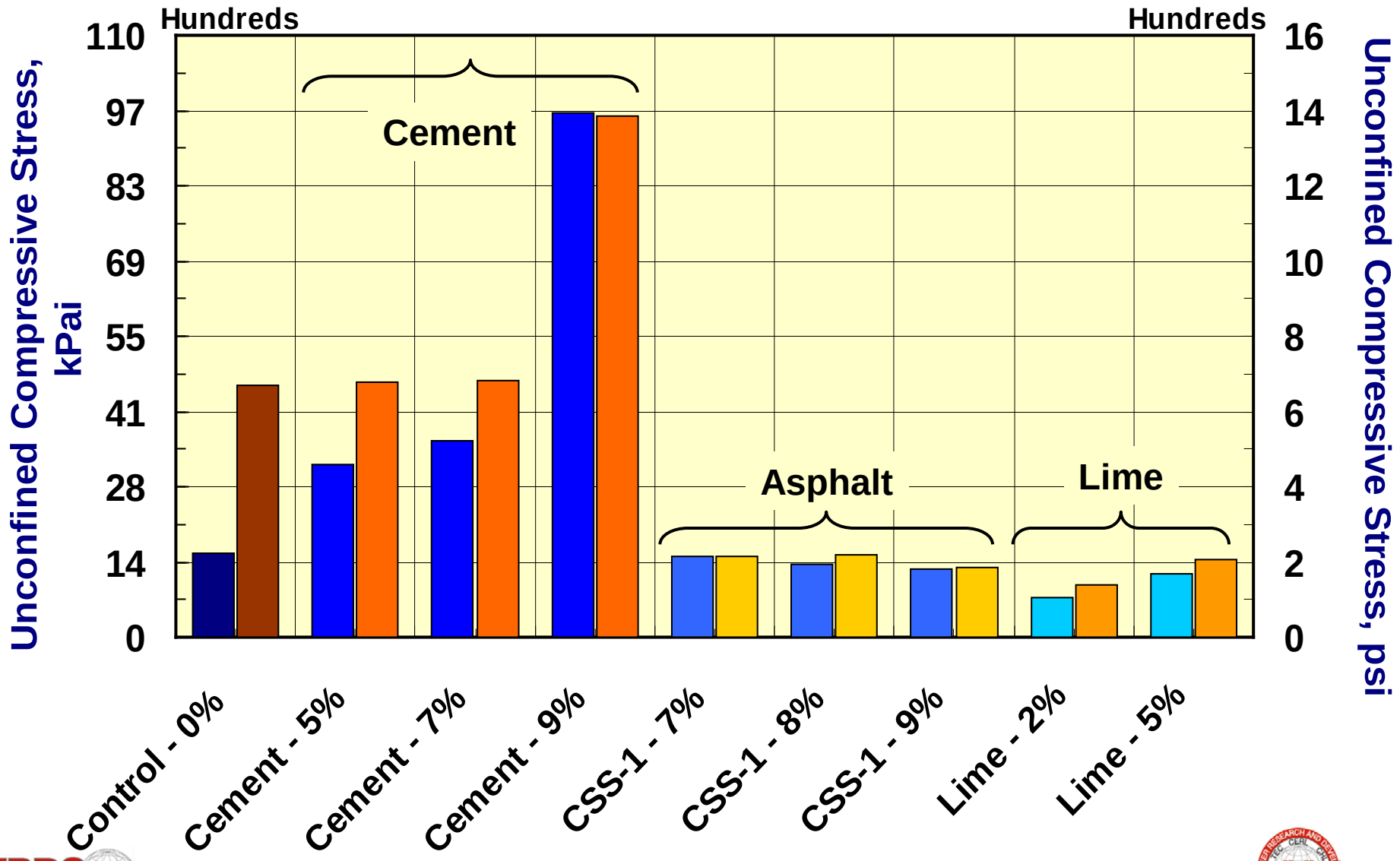
Stabilization of SM Sands with Nontraditional Additives

Effect of Stabilizer Type



Stabilization of SM Sands with Nontraditional Additives

Effect of Stabilizer Type

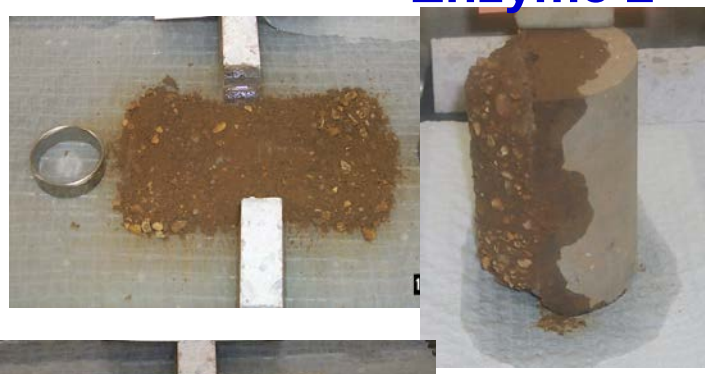


Stabilization of SM Sands with Nontraditional Additives

Effect of Wet and Dry Conditions

- **Disintegration**
  - Loss UC strength
  - Alter cross section area
- **Waterproofing**
  - Prevent loss of fines
  - Potential for dust control

Enzyme 2



Tree Resin 1

Stabilization of SM Sands with Nontraditional Additives

Effect of Wet and Dry Conditions

Poor Performers

- Enzymes
- Acid 1
- Lignosulfonate 2

Enzyme 1

Acid 1

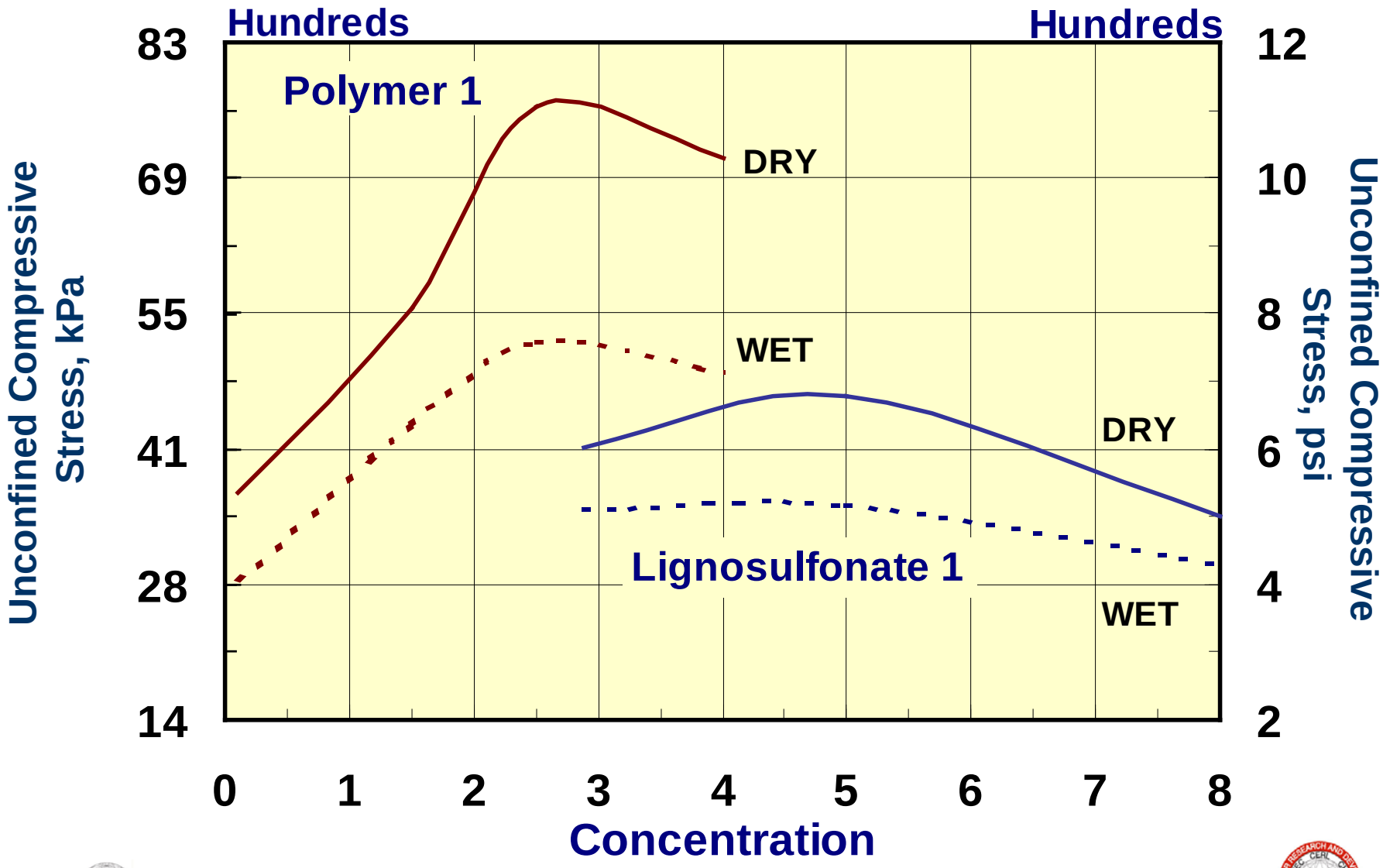
Excellent Performers

- Polymers
- Cement

Lignosulfonate 2

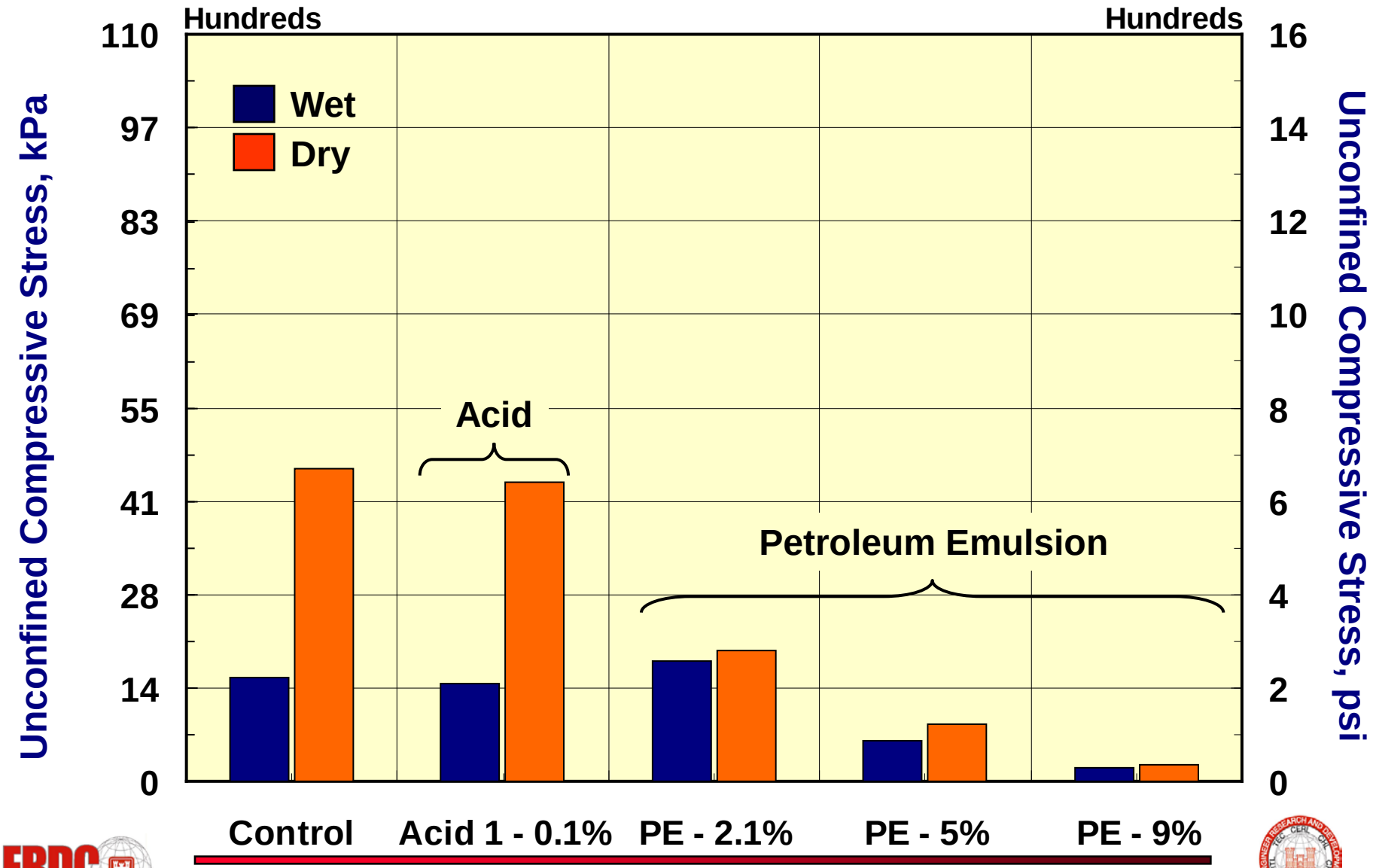
Stabilization of SM Sands with Nontraditional Additives

Effect of Additive Quantities

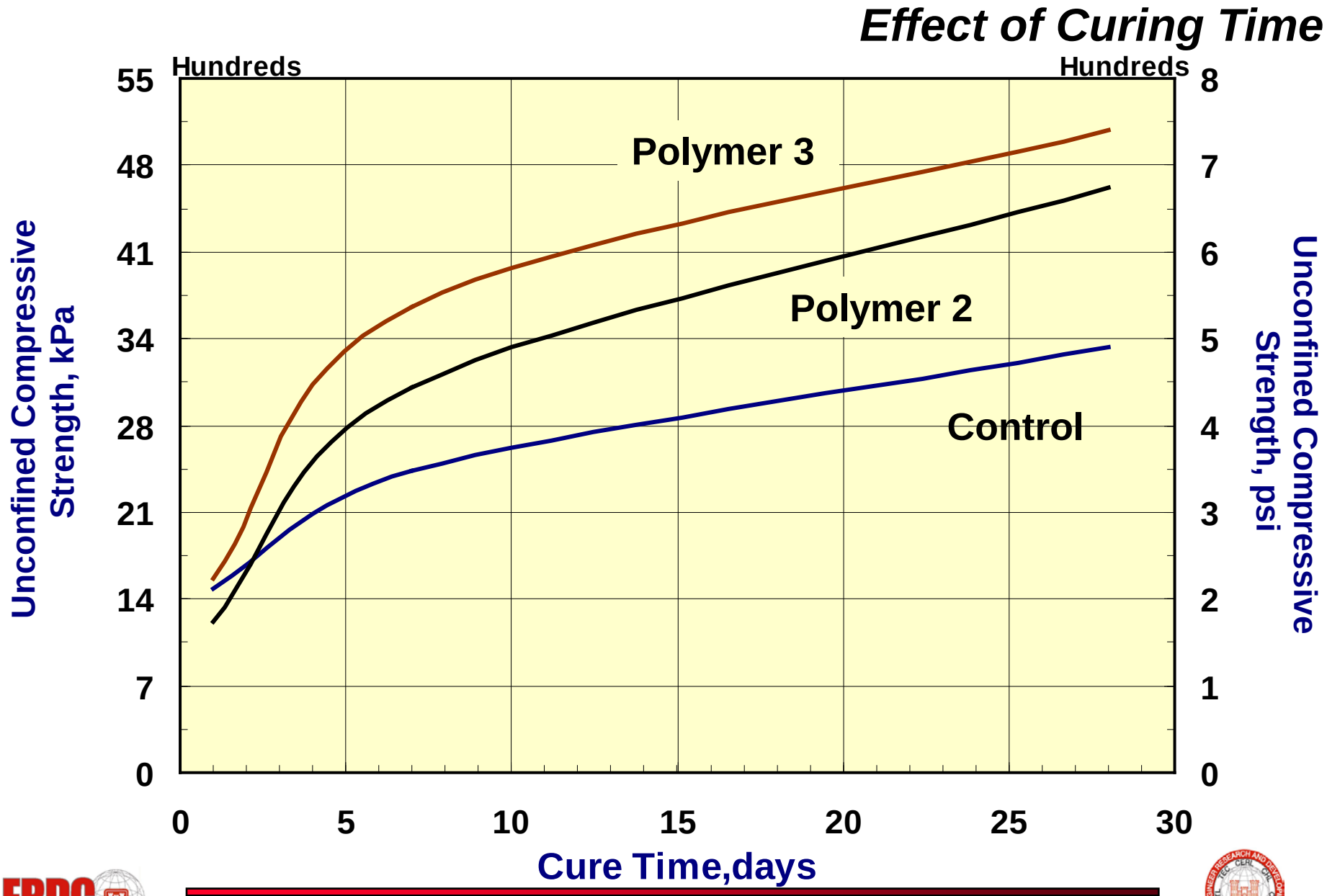


Stabilization of SM Sands with Nontraditional Additives

Effect of Additive Quantities



Stabilization of SM Sands with Nontraditional Additives



Stabilization of SM Sands with Nontraditional Additives

Repeatability of Tests

Samples

- Wet Condition – 3 samples
- Dry Condition – 3 samples

Variability

- Height – 2.54 to 5.08 mm
- Water Content – 0 to 0.5 %
- Dry Density – 0-19 kg/m^3
- UC Strength – 0-110.3 kPa

Stabilization of SM Sands with Nontraditional Additives

Summary

Conclusions

- Polymers and cement excellent stabilizers
- Waterproofing potential
  - Petroleum Emulsion 1
  - Tree Resin 1
  - Lignosulfonate 1
- Optimum additive quantity
  - Enzymes < 1
  - Lignosulfonates – 5%
  - Petroleum Emulsion – 2%
  - Polymers – 2.5 to 5%
  - Tree Resin – 9%
- Nontraditional stabilizers gain strength quicker

Stabilization of SM Sands with Nontraditional Additives

Summary

Recommendations

- Evaluate long-term performance
- Conduct field condition and traffic loading
- Establish stabilization mechanisms