SOILS & STRUCTURES

- Soil Stabilization -

Applications & Design

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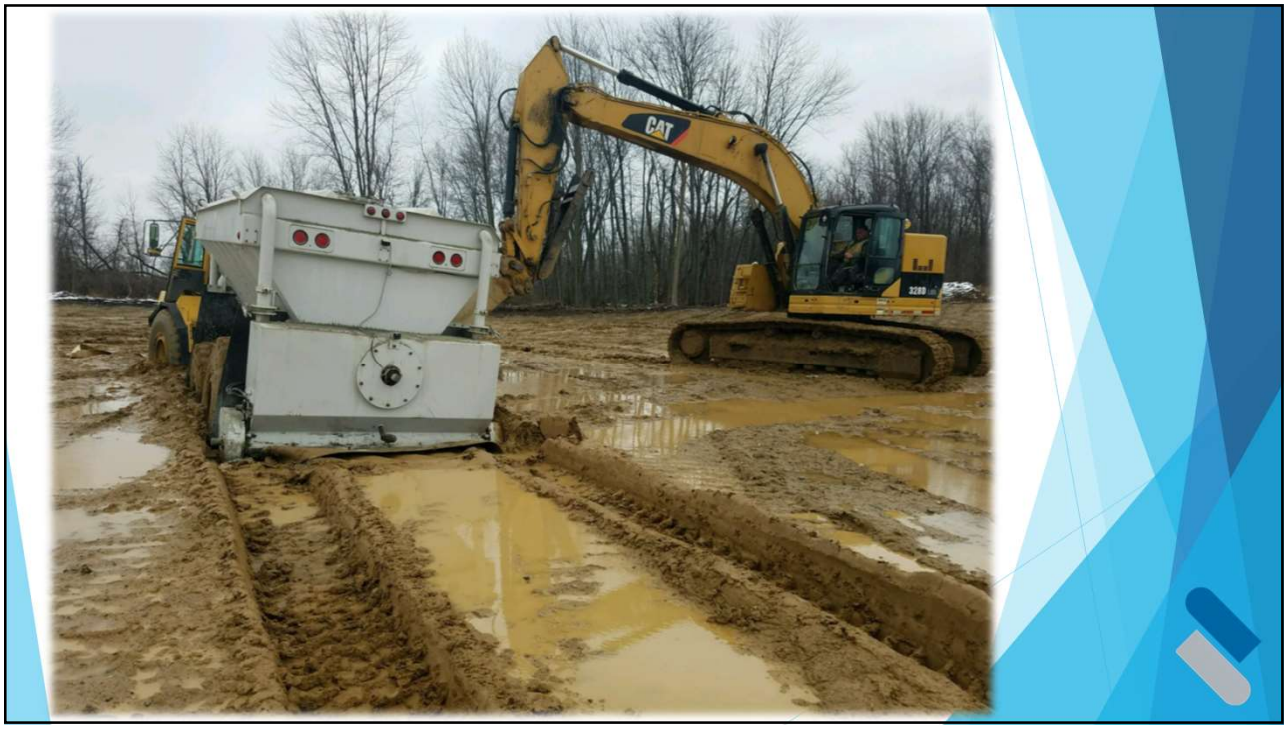
Outline

- Equipment and Process
- Additive Types
- Different Systems
  - Design Methodology
- Sub-grade Design/Modeling
- Challenges
- Summary/Whats Next?/Q&A


CAT


CATERPILLAR
D3C XL
Hystat
DZ 202
CAT

Chemical Stabilization and/or Modification Process

- Prep Site
  - Pre-Pulverize, Rough Grade, Moisture Condition
- Apply Additive
- Process Additive & Engineered Portion of Soil/Pavement
- Initial Compaction
- Fine Grading
- Final Compaction
- Post Conditioning
- Surfacing

Equipment

Additive Supply Pneumatic Bulk Trailers

Additive Supply - Storage

Site Spreaders

Site Spreaders - Fabrication

Soil Stabilizer & Cold Recycler

Soil Stabilizer & Cold Recycler

Soil Stabilizer & Cold Recycler

Pad-Foot Roller


Water Truck


Direct Injection

Stabilization vs Modification

What are we trying to accomplish?

Predominate Soil Characteristics

- Crushed Aggregates
- Well Graded Granular Soils
- Poorly Graded Granular Soils
- Lean/Low Plasticity Clay Soils
- Fat/High Plasticity Clay Soils
- Deal Breakers (Soluble Sulfates or Highly Organic)

Stabilization vs Modification

Common Additives

Lime Kiln Dust (LKD)

Quicklime

Flyash

Portland Cement

Asphalt Emulsion

What is Lime ?

Compound, wt%	Ignited Basis	As-Received Basis
Silicon Dioxide	9.11	6.76
Aluminum Oxide	4.41	3.27
Iron Oxide	1.36	1.01
Calcium Oxide	77.39	57.43
Magnesium Oxide	2.65	1.97
Sodium Oxide	0.23	0.17
Potassium Oxide	0.57	0.42
Titanium Oxide	0.17	0.13
Manganese Dioxide	0.04	0.03
Phosphorous Pentoxide	0.05	0.04
Strontium Oxide	0.06	0.04
Barium Oxide	0.01	0.01
Sulfur Trioxide	3.58	2.66
Chloride	0.37	0.27
Moisture		0
Loss on Ignition		25.79
Available Lime Index, %CaO		22.55

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Available Lime?
Free Calcium

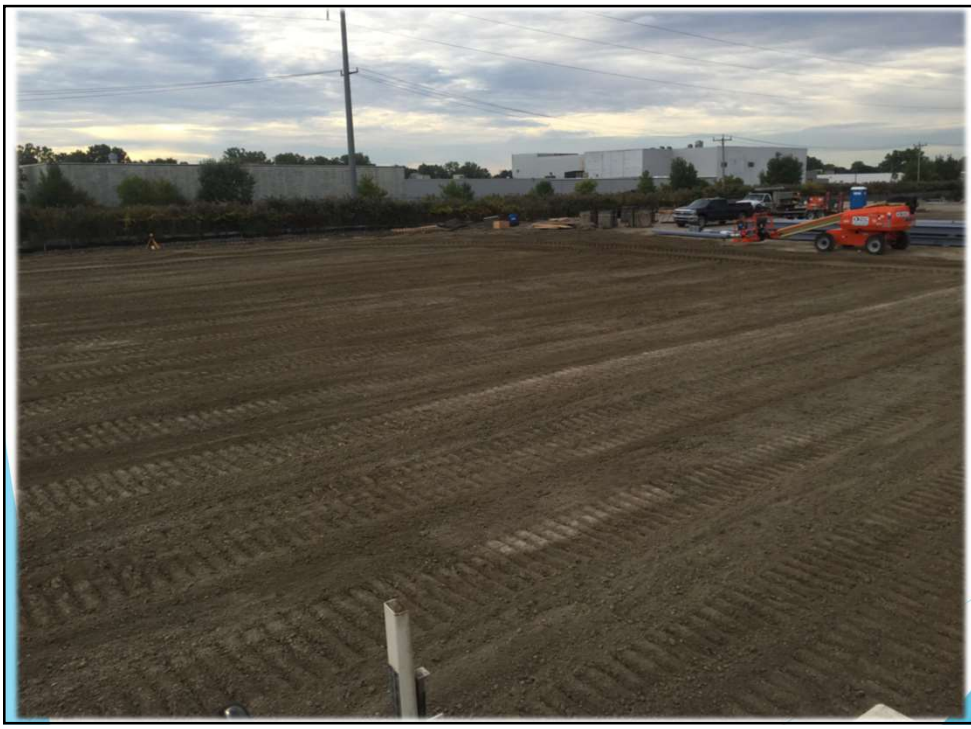
https://www.youtube.com/watch?v=2n46c6KWris

Subtle Modification & Soil Drying

Undocumented Fill

Contaminated Soils

Low Plasticity Soils



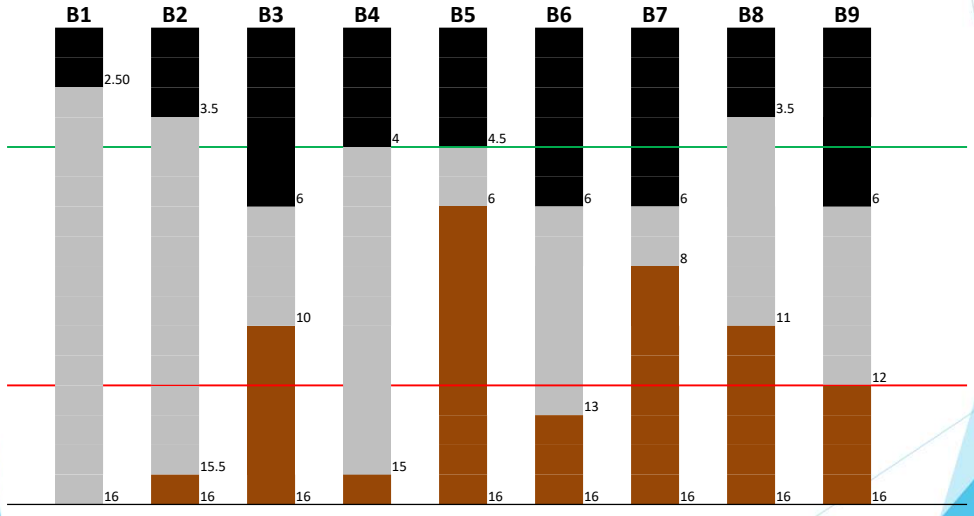
Short Term Structural Improvement

Paveable Surfaces (S)tabilized (B)ase (Course)

Granular Soils and Low Percentage Cohesive Soil Blends

Full Depth Reclamation

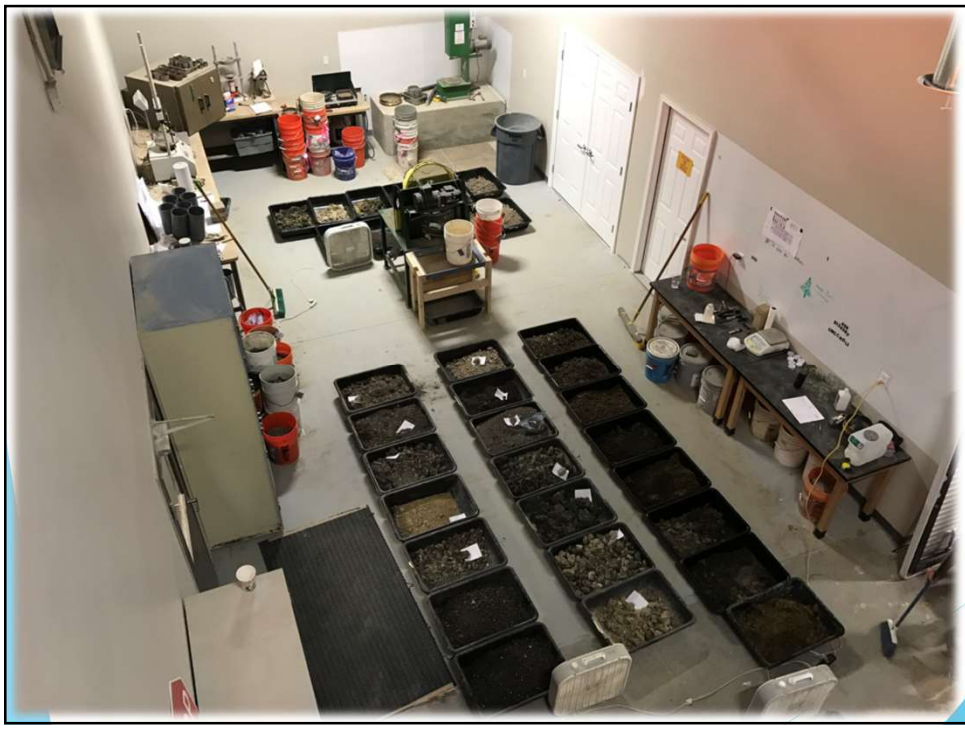
Best Candidates – Pre Mill vs Pre Pulverize



Particle Size Distribution

Relatively Granular

Variable Conditions



Bulk Sampling

Indexing

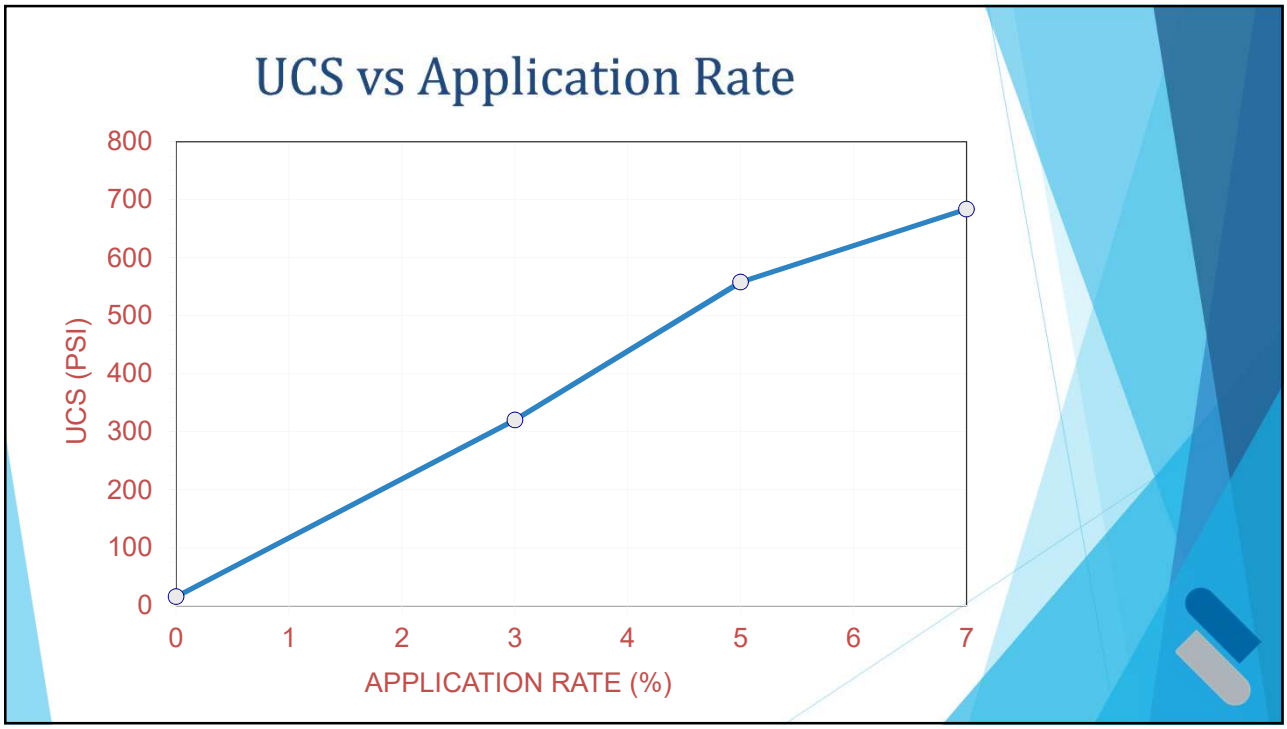
- Particle Size Distribution – Hydrometers and Sieves
- Atterberg Limits – LL/PL
- Soluble Sulfate Analysis
- Moisture Density Relationships

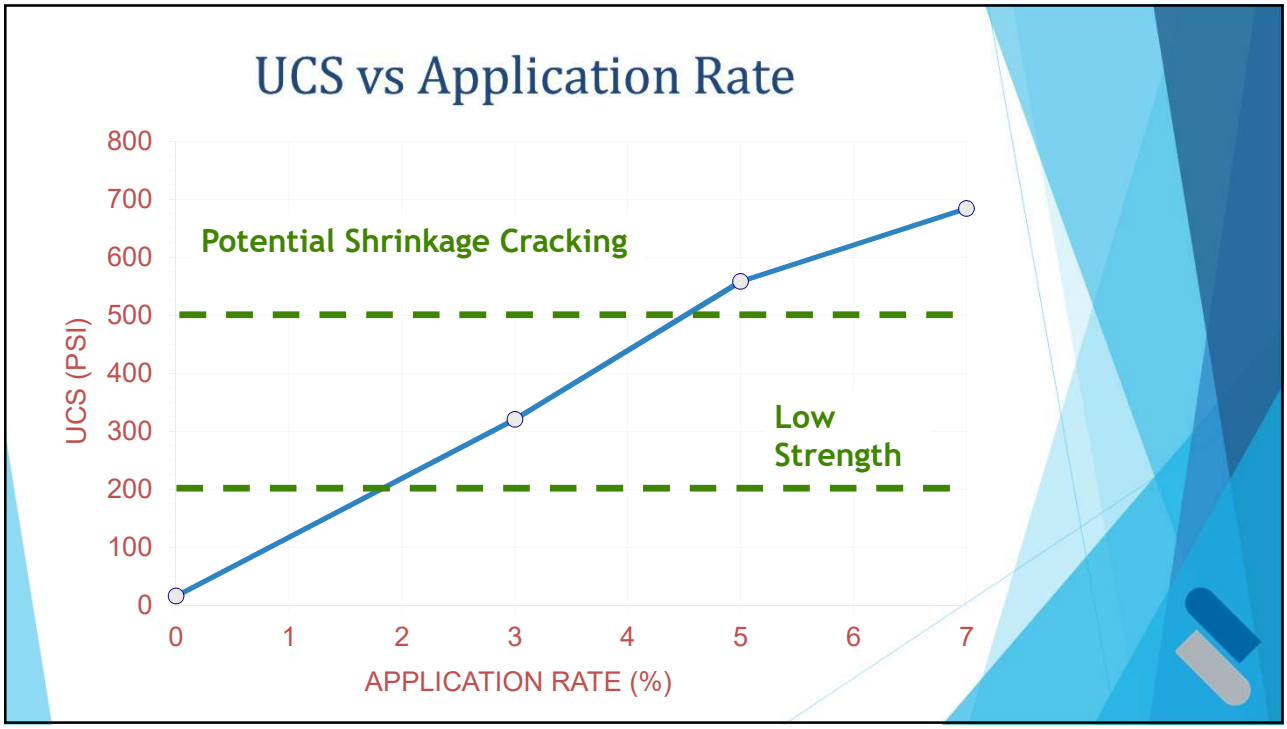
Variable Application Rates

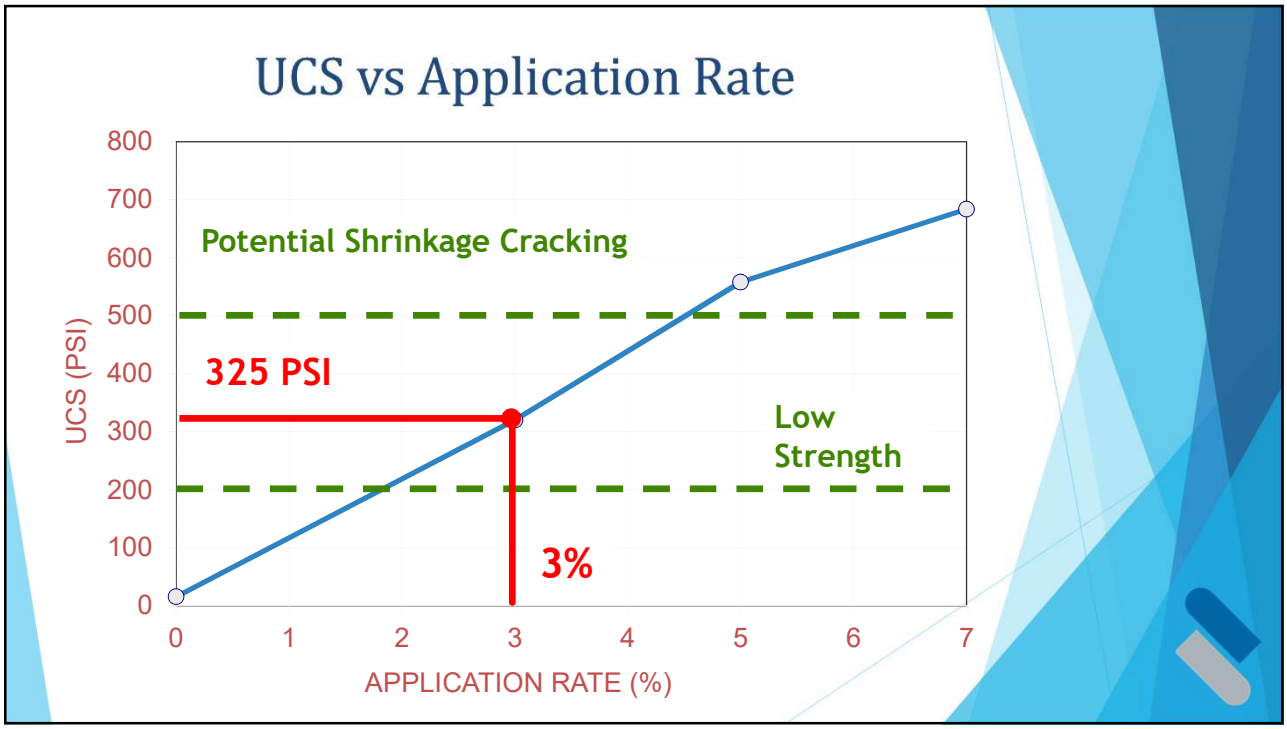
Percent By Mass

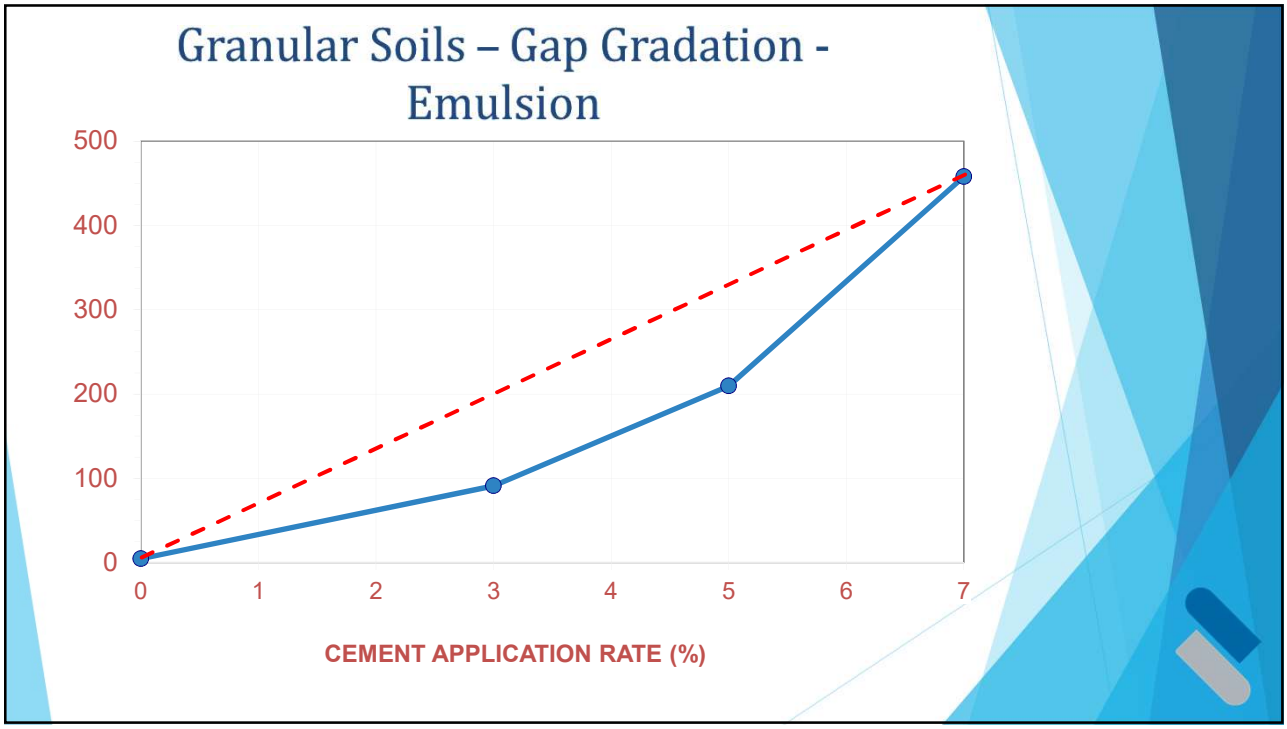
(U)n-confined
(C)ompressive
(S)trength

Brittle Vs. Ductile?


UCS vs Application Rate
800
700
600
500
400
300
200
100
0
UCS (PSI)
0
1
2
3
4
5
6
7
APPLICATION RATE (%)


UCS vs Application Rate
800
700
600
500
400
300
200
100
0
UCS (PSI)
Potential Shrinkage Cracking
Low
Strength
0
1
2
3
4
5
6
7
APPLICATION RATE (%)


UCS vs Application Rate
800
700
600
500
400
300
200
100
0
UCS (PSI)
Potential Shrinkage Cracking
325 PSI
Low
Strength
3%
0
1
2
3
4
5
6
7
APPLICATION RATE (%)


Granular Soils – Gap Gradation - Emulsion
500
400
300
200
100
0
0
1
2
3
4
5
6
7
CEMENT APPLICATION RATE (%)

Bituminous Materials

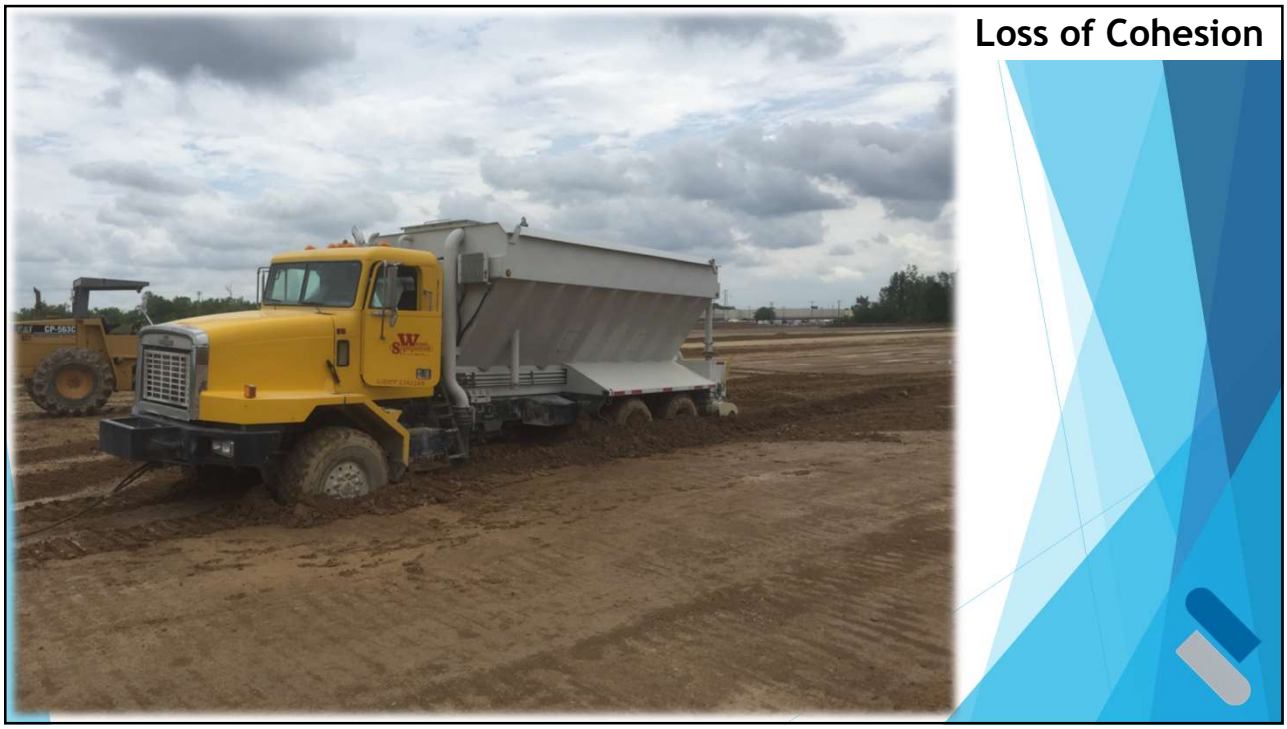
Material Consistency – Layer Thickness

HFRE vs Engineered Emulsions

- Moisture Content and Total Fluids
- Risk Associated with Trapping Water
- Active Fillers

Hybrid Stabilization Paveable Surfaces & Subgrade

High Percentage Lean Cohesive Soils Blends



Loss of Cohesion

70% Lean Clay

Long Term Strength

Pozzolanic Interactions

Lime Stabilization

Fat Clays & Expansion Potential

Liquid Limit 81

Expansion Potential

Friable

Controlled PI

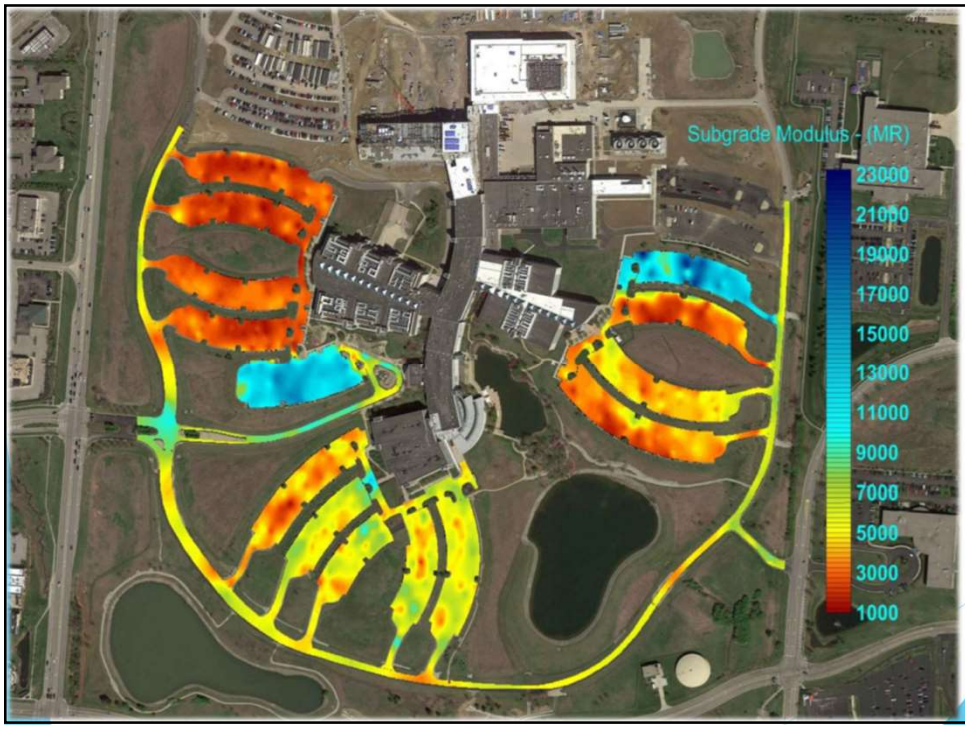
Interior and Exterior

Sensitive Process

Long Term Strength in Sub Grade

PH 12.45

Modeling



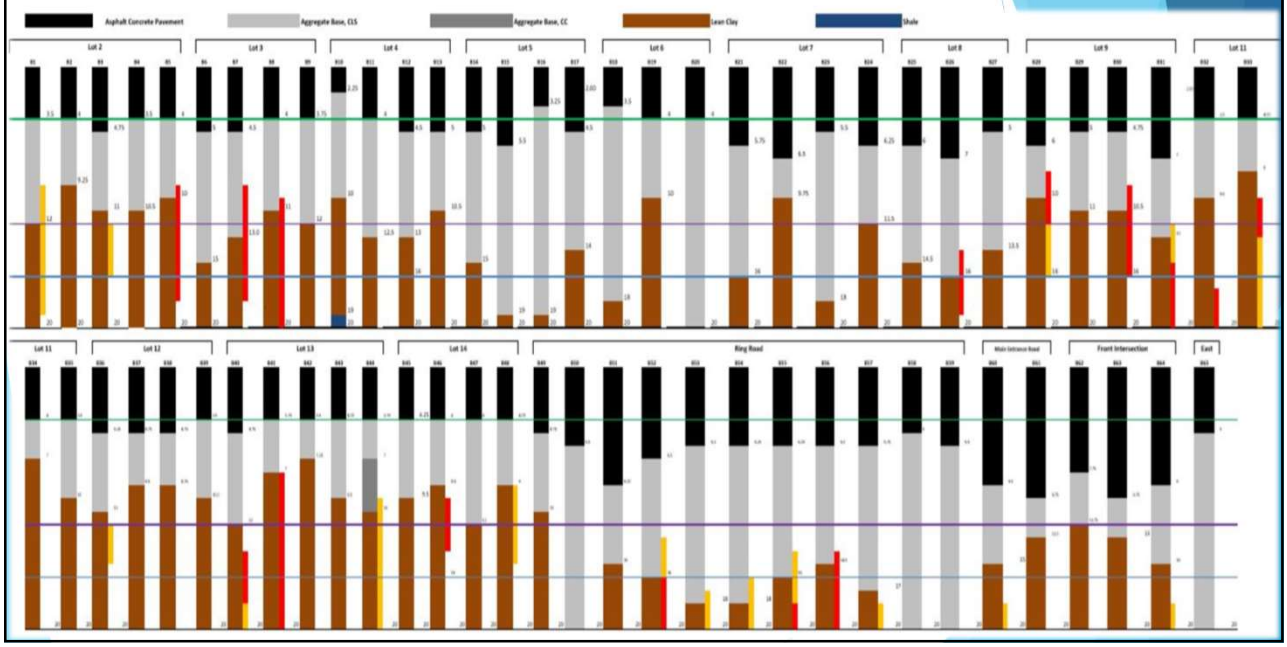
Site Characterization

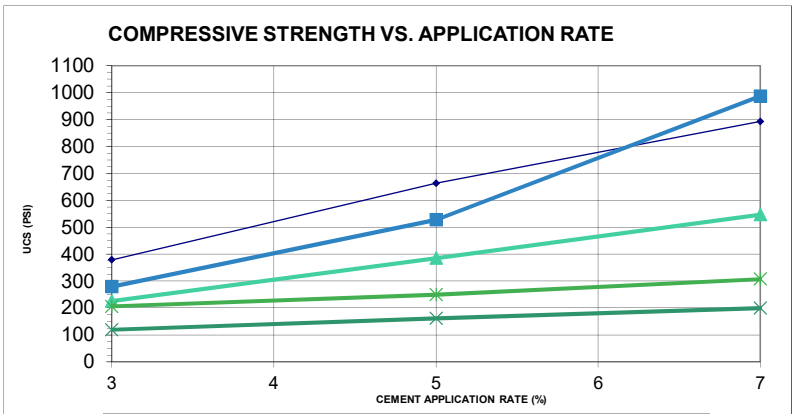
Structural Number

APPARENT Sub-grade Reaction

Global Support

High Resolution Exploratory vs High Resolution Design



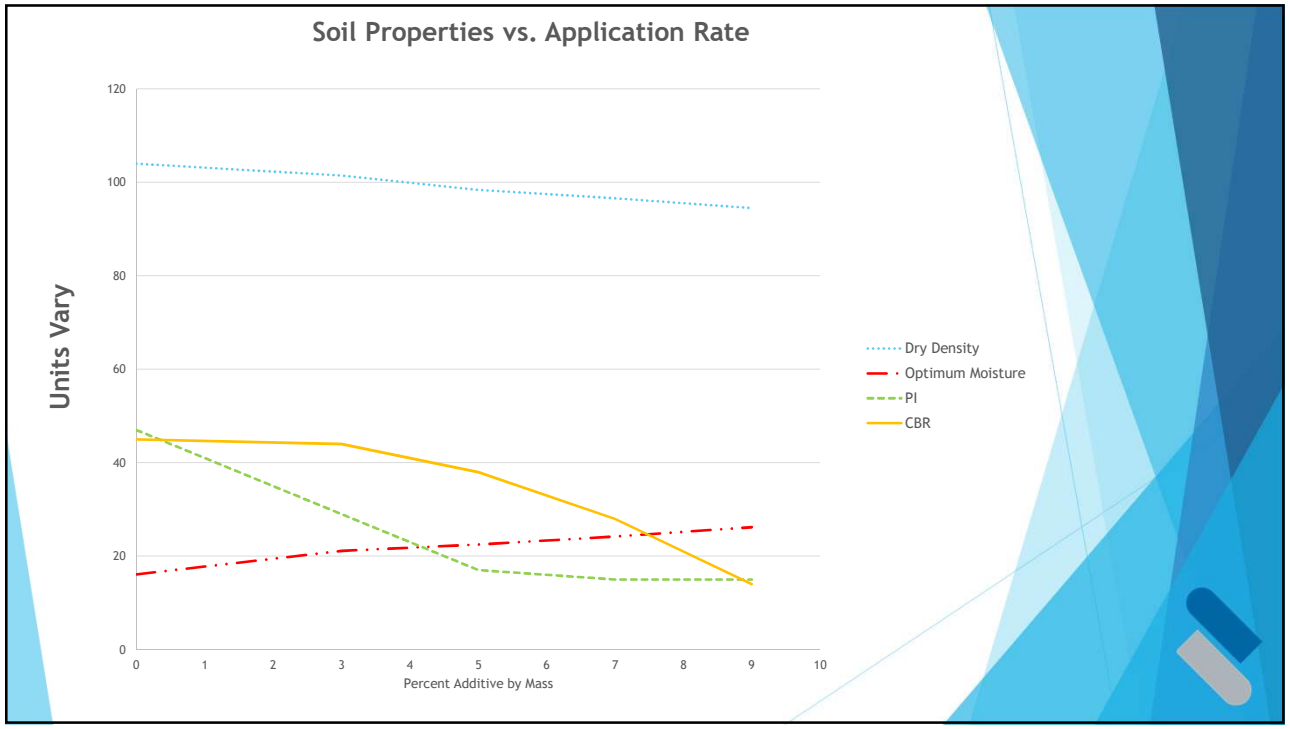


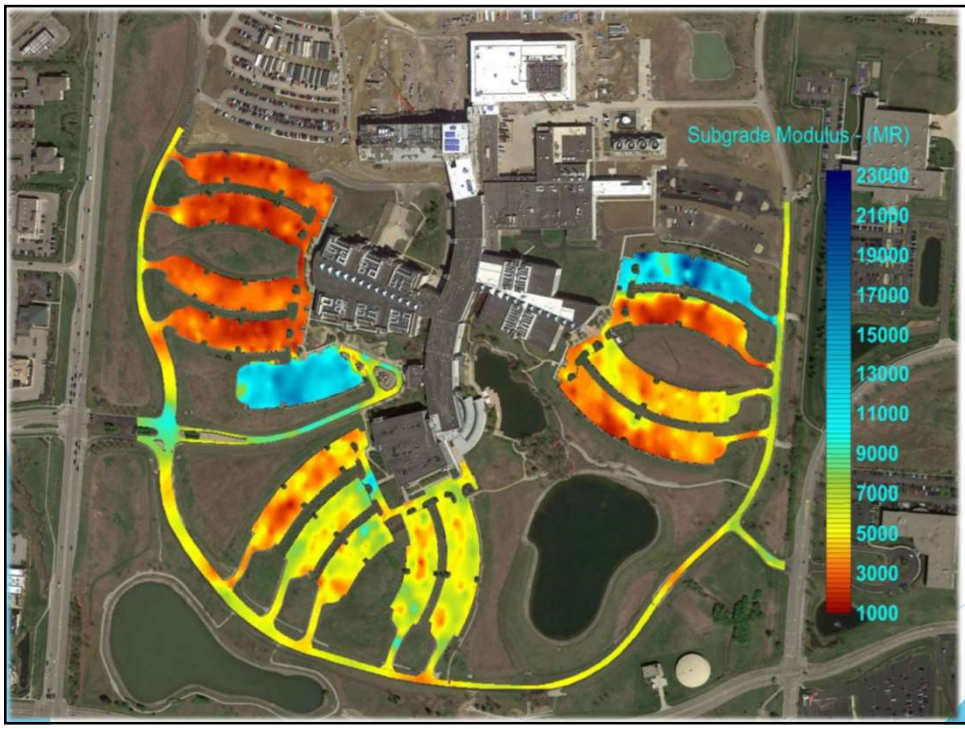
Site Characterization

1	25% Asphalt, 75% Aggregate Base, 0% Sub-Grade	131.5	5.5%
2	25% Asphalt, 65% Aggregate Base, 10% Sub-Grade	135.0	7.0%
3	25% Asphalt, 45% Aggregate Base, 30% Sub-Grade	134.0	8.5%
4	25% Asphalt, 25% Aggregate Base, 50% Sub-Grade	129.5	9.5%
5	25% Asphalt, 15% Aggregate Base, 60% Sub-Grade (LKD Pretreated)	125.0	10.5%

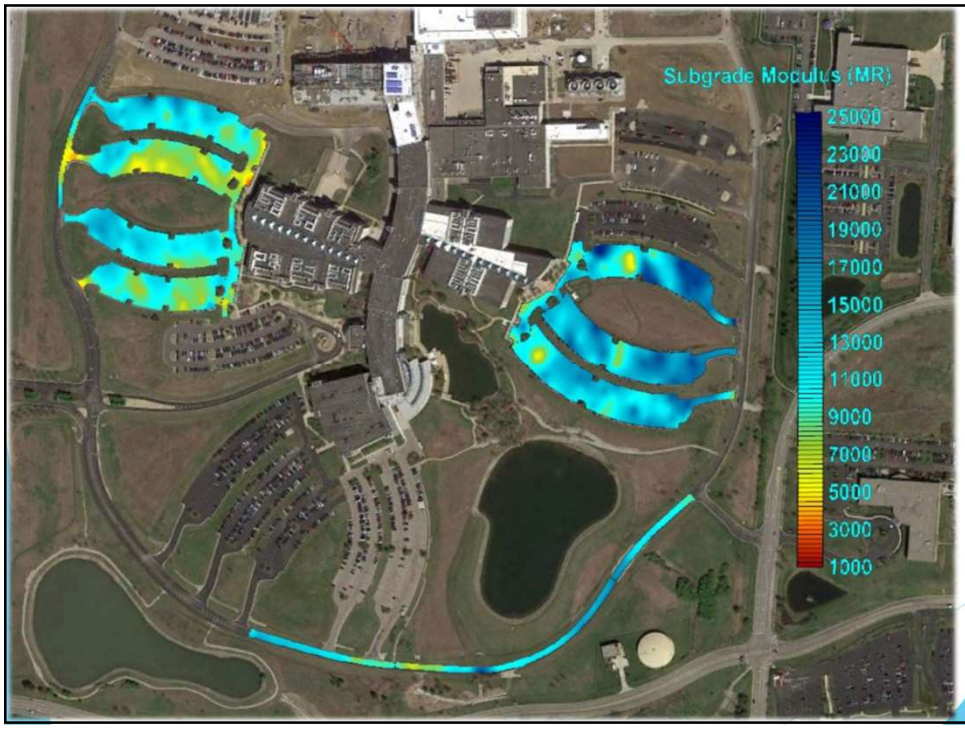
CBR?

Brittle Vs. Ductile?





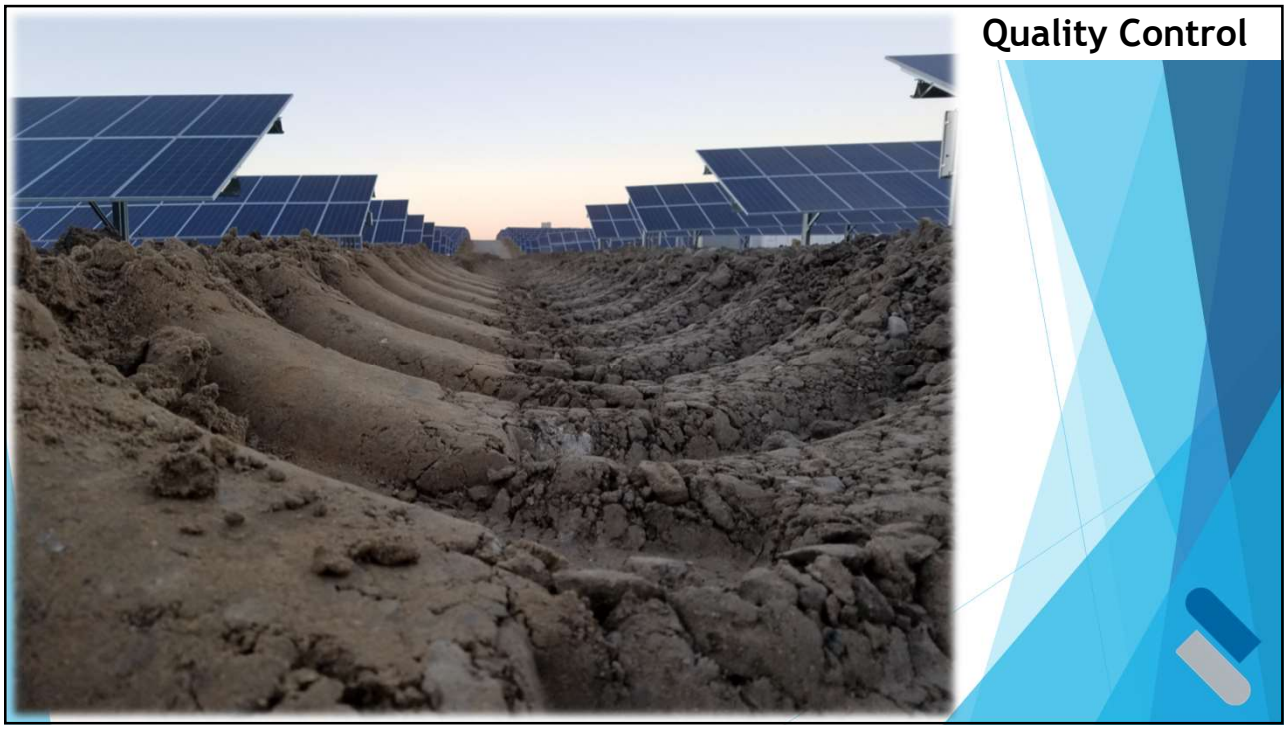
Correlating to Field



Correlating to Field

Challenges

Grade Control - Survey



Quality Control

Loss of Cohesion

Loss of Cohesion

Expansion

Summary

Cost/Benefit

- 30% Reduction in construction cost vs undercutting
- Substantial reduction in construction time
- Reduced environmental impact
- Possible to minimize overlay thickness due to increased structural support of base and/or sub-grade
- Reduction in construction contingencies for site preparation on very poor sites or long term projects
- Substantial increase in target design life for high volume roads incorporating stabilized subgrades.
- Cost of implementing is negligible compared to overall construction cost on mega projects
  - Particularly when considering 2nd and 3rd life cycle for long term designs

Moving Forward

- Continuing to develop specifications to accommodate better geotechnical design
- Working with existing data to develop Michigan specific materials database
- 6 year mark for current case studies. Working to review conditions and update lifecycle database
- US – 131 and I – 69 installed this year, continuing conversations on establishing long term case studies for stabilized subgrades on trunkline projects.

SOILS & STRUCTURES

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Thank You

Any Questions?