Mitigation of Swelling Soil-Induced Problems in Oklahoma Using Chemical Injections

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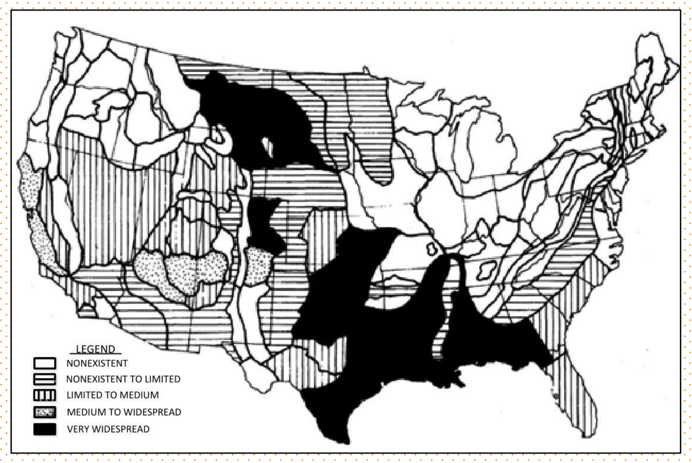
Objectives

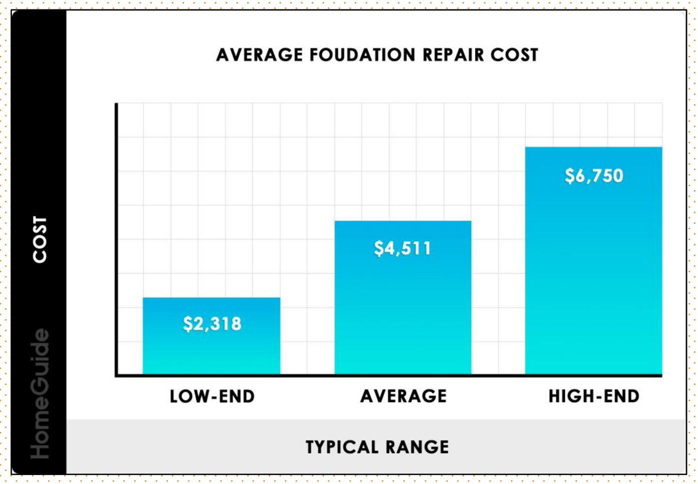
- Effectiveness of chemical injection in mitigating problems associated with expansive soils in Oklahoma.
- Time and cost effectiveness of chemical injection methods.
- Chemical injections in the laboratory to determine optimal injection parameters.
- Selective field injections for verification and demonstrate application.

Background

- Billions of dollars spent annually to address infrastructure damages caused by expansive soil.
- Can be mitigated through proper stabilization methods.
- Traditional stabilization methods may be expensive and not as effective.
- Major challenges in constructing basements or shelters in presence of expensive soil, particularly using traditional stabilization methods.



Distribution of expansive soil prone areas throughout the U.S.



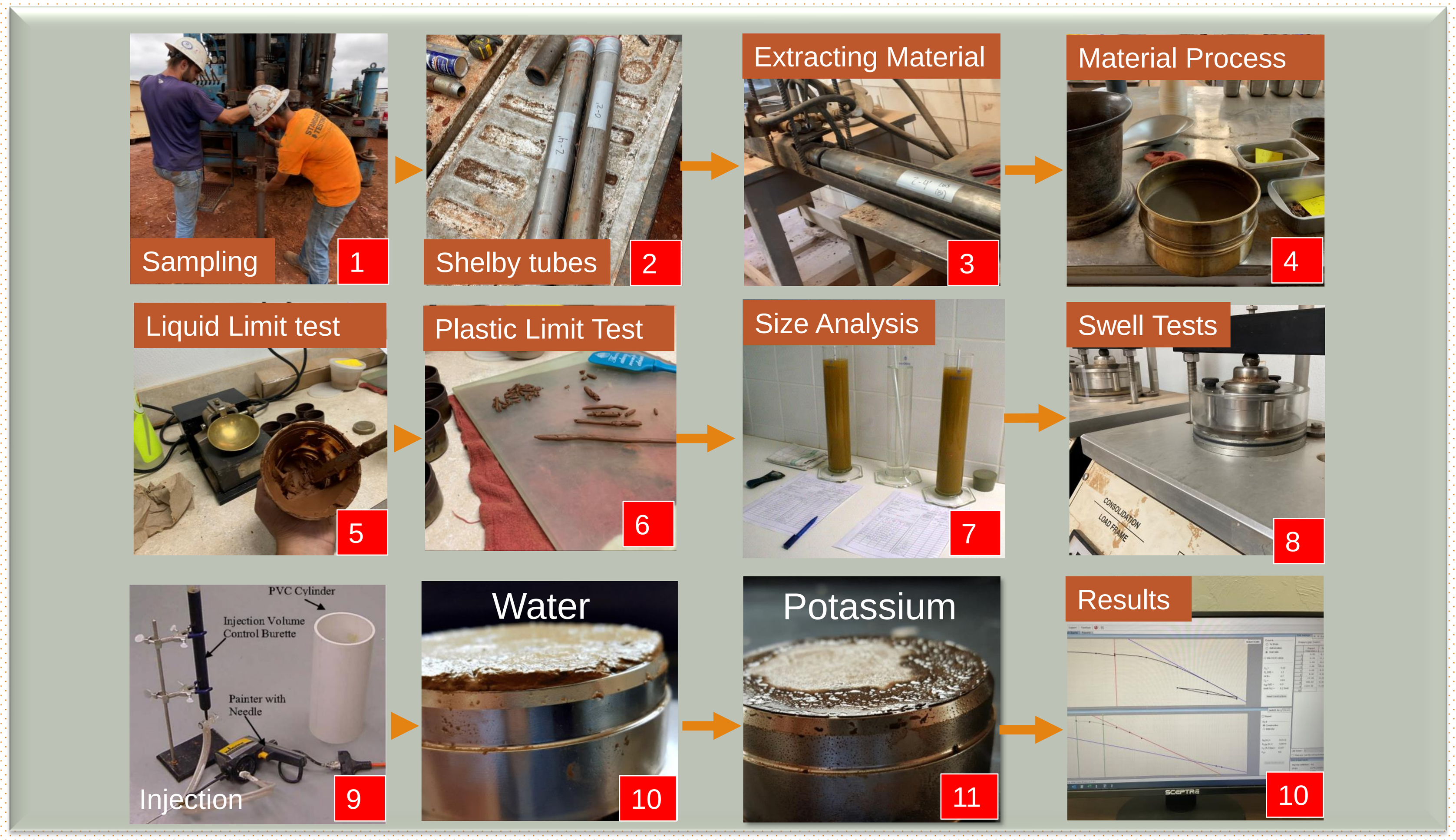
Experimental program

- Collection of in-situ samples from different projects in Oklahoma.
- Laboratory testing in Atterberg limits (ASTM D4138), Grain size analysis (ASTM D422), One-Dimensional swell (ASTM D4546 Test method B) and Linear shrinkage (Tex-107-E)
- Effect of chemical injection parameters on Plasticity index (PI), potential vertical rise (PVR), swell pressure and free swell.

Types of injections

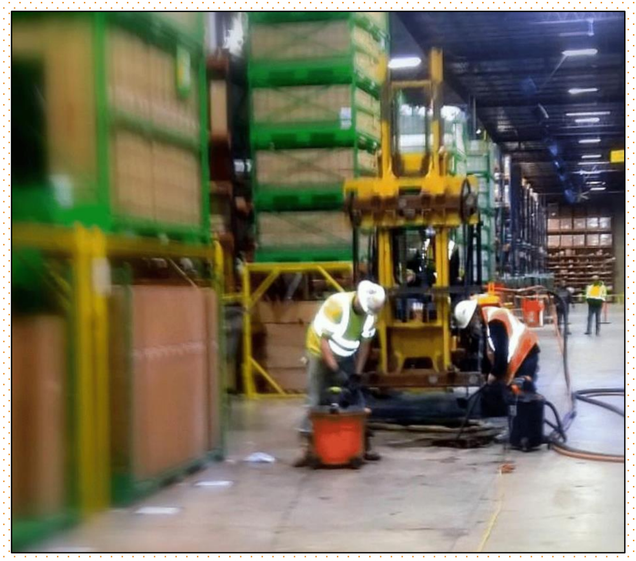
- Potassium → Swell Inhibitor → Potash, Lignin, Caustic Soda, Water
- Water → Pre-swelling of Clays
- Slurry → Increment the soil strength → Cement, Fly-Ash, Lime

Laboratory performance test



Field application

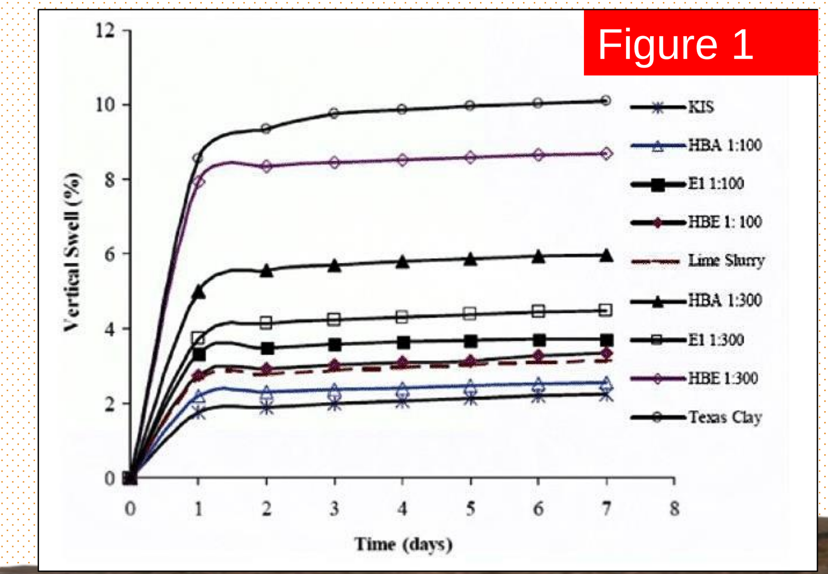
Indoor single rod unit for low headroom conditions. Used here at the Tulsa Hills Shopping Center



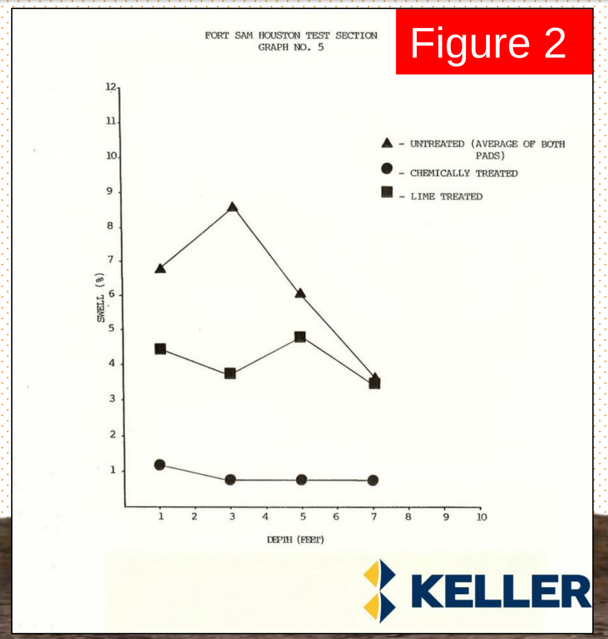
Indoor multi-rod units for elevated interior spaces

Outdoor standard depth 10 feet usually push 3 to 5 probes

Historical results from selected projects



Effectiveness of chemical stabilizers on expansive clay research. KIS (Potassium solution) indicated the most resistance to swell with 75% reduction in swell compared to the untreated sample and seven other solutions.



"Lime and Potassium solutions tested on an untreated soil sample from Forth Sam Houston. Potassium treatment resulted as the best stabilization."

Discussion of the historical results

- Figure one:
  - Laboratory experiments in Texas by KSCE Journal of Civil Engineering (2014) 18(4):1009-1017.
  - Soil sample The samples initially pre-swelled and then injected with different solutions.

Specimen	Initial WC	Initial dry	Vertical Swell (%)	Final WC	Final dry	Chg WC/S	(Chg. dry/Ini. dry X S) 100
	%	kN/m³	7 days	%	kN/m³	---	Per % S
KIS 1	19.5	13.78	2.25	34.0	13.47	6.44	1.00
KIS 2	21.8	13.84	2.58	32.9	13.48	4.30	1.01
E1 1:100	21.5	17.74	4.57	32.4	14.27	2.52	4.28
E1 1:300	20.8	17.60	4.48	30.4	14.47	2.13	3.97
HBA 1:100	21.8	14.67	.55	32.6	14.31	4.24	0.96
HBA 1:300	21.4	17.72	5.96	31.2	14.31	1.65	3.23
HBE 1:100	21.7	18.00	5.16	32.5	14.46	2.37	3.81
HBE 1:300	21.3	17.68	8.68	31.8	13.78	1.21	2.54
Lime	21.1	17.18	3.15	32.9	13.85	3.74	6.15

- Figure two:
  - Relative effectiveness of lime and potassium in stabilizing expansive soils in San Antonio, Texas.
  - Certain level of success in reducing swell in both cases.
  - Lime treatment required repeated injections.
  - Potassium treatment did not require repeated injections, hence more efficient.

Anticipated conclusions

- Highest PVR reduced to less than 1-inch; PI values reduced significantly; significant reduction in shrink and swell potential due to stabilization.
- Chemical injections can be a cost-effective solution for expansive soil in Oklahoma
- Chemical injection cheaper (at least 25%) than traditional methods used in Texas.
- Success seen in Texas in chemical injection treatment of expansive soil may be replicated in Oklahoma.

Acknowledgements

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