TxDOT Guidelines for Soil Stabilization

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Geotechnical Soils & Aggregates Branch, CST/M&P

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Outline

- What is soil stabilization?
  - Mechanical soil stabilization
  - Chemical soil stabilization

- Why do we need it?

- How do we do it?

- Sulfate-induced soil heave?
  - What is the problem?
  - How do we deal with it?
Do we really need soil stabilization?
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Do we really need soil stabilization?
How Do We Do it?

- **Identify** the goals of soil stabilization
- **Select** the appropriate type and amount of stabilizers
- **Evaluate** the material properties and field performance to ensure the designed goals of soil stabilization have been achieved
Goals of Stabilization

- Dry up construction site and provide a working platform
- Reduce soil PI and clay/silt-sized particles
- Improve compactability
- Reduce shrink/swell of expansive soils
- Improve strength and stability
- Reduce moisture susceptibility
- Utilize local or salvaged materials
Chemical Stabilizers

- **Traditional Stabilizers**
  - Lime
  - Cement
  - Fly Ash
  - Asphalt and Asphalt Emulsion
  - Any combination of above

- **Other Stabilizers**
  - CKD – Cement kiln dust
  - LKD – Lime kiln dust
  - GGBFS – Ground granulated blast furnace slag
  - Liquid stabilizers (a.k.a. Snake oil) – Not recommended
Selection of Stabilizers

- Goals of treatment
  - dry up, PI, strength, modulus, shrink/swell

- Soil type
  - classification, mineralogy, sulfate, and organics

- Material availability

- Construction costs and time

- Traffic load and volume

- Design life of pavement structure

- Environmental conditions
  - drainage condition, ground water table, precipitation, temperature

- Overall benefits of the improved structural, material, and construction performance
  - cost savings vs. benefits
TxDOT Guidelines for Soil Stabilization

Sieve Analysis & Atterberg Limits

Base
< 25% Passing No. 200 Sieve

PI < 12
- Cement
- Fly Ash (CS)
- Asphalt (PI < 6)
- Lime

PI ≥ 12
- Lime-Cement
- Lime–Fly Ash (FS)
- Lime
- Cement

Subgrade
≥ 25% Passing No. 200

PI < 15
- Cement
- Asphalt (PI < 6)
- Lime
- Lime-Cement
- Lime–Fly Ash (FS)
- Fly Ash (CS)
- Cement

15 ≤ PI < 35
- Lime
- Lime-Cement
- Lime–Fly Ash (FS)
- Fly Ash (CS)
- Cement

PI ≥ 35
- Lime
- Lime-Cement
- Lime–Fly Ash (FS)
- Fly Ash (CS)
- Cement

Road or Plant Mixed

Cement  TxDOT Spec Items  275 or 276  Test Method Tex-120-E
Lime    TxDOT Spec Items  260 or 263  Test Method Tex-121-E
Fly Ash TxDOT Spec Item  265        Test Method Tex-127-E
Asphalt TxDOT Spec Item  292        Test Method Tex-126-E
Summary of Guidelines

- Select a type of stabilizer based on soil classification (gradation and PI) and the goals of soil stabilization.

- Perform a proper mix design to determine the optimum amount of the selected stabilizer on a project basis for the desired engineering performance.

- Perform evaluation tests to ensure the engineered mix meets the goals and requirements of soil stabilization.
Key Points of Guidelines

- Soils are different
- Stabilizers are different
- Reactions between soils and stabilizers are different
- DO A MIX DESIGN
- Evaluate the material properties and field performance
Guidelines for Sulfate-bearing Soil Stabilization

- What is sulfate-induced soil heave problem?
- What cause the problem?
- How to I know I have sulfate in my soils?
- What sulfate concentrations are too high for traditional soil stabilization?
- What stabilization procedures should be followed for high sulfate-bearing soils?
What Is Sulfate Heave and What Causes Problem?

Lime/cement/fly ash (Class C) (Calcium, high pH) + Clay minerals (Alumina, at high pH) + Sulfate minerals (Sulfur) + Water (H₂O) = Ettringite (C-A-S-H, calcium-aluminate-sulfate-hydrate)
Hump and Cracking area

SH6, NB, Falls County, Waco
What Causes Sulfate Heave?

Sulfate-induced Heave

Intersection of SH130 and US287, Childress
How to Detect Sulfates?

How to identify sulfate?
- USDA soil survey map and reports
- Field visual inspection and verification by coring/boring
- Consult with CST/M&P

How to determine sulfate concentration?
- Conductivity test (Tex-146-E)
- Colorimetry test (Tex-145-E)
Verification by coring/boring
Gypsum Crystals

Intersection of SH130 and US290, Austin

Eagle Pass, Laredo
Conductivity and Colorimetry

![Graph showing Conductivity and Sulfate Concentration](image)

- **Conductivity, mS**
  - **2360** (HS)
  - **480** (LS)

- **Sulfate Concentration, ppm**
  - **35540** (HS)
  - **6772** (LS)
Unconfined Compressive Strength

Material Type

UCS, psi

Raw | 5% Lime | 3% Cement | 2% Lime + 12% FA | 2% Lime + 6% Slag

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Three-Dimensional Swell of Soils

Bar chart showing volume expansion for different material types:

- **Raw**: 3.9 (HS), 0.2 (LS)
- **5% Lime**: 17.9 (HS), 7.3 (LS)
- **3% Cement**: 15 (HS), 4.4 (LS)
- **2% Lime + 12% FA**: 2.5 (HS), 0.1 (LS)
- **2% Lime + 6% Slag**: 5.7 (HS), 2.6 (LS)
Summary of Detecting Sulfate

- USDA sulfate survey map
- Field visual inspection and verification by coring/boring if necessary
- Conductivity is a fast screening test in field for possible sulfates (> 250 $\mu$S/cm)
- Colorimetry is a fast, accurate sulfate test in lab
TxDOT Guidelines

If sulfate concentration in soil is:

- **< 3000 ppm**: Proceed with TxDOT Spec.
- **> 3000 ppm, but < 8000 ppm**:
  - Use as much water as possible during construction (3 to 5 % above OMC)
  - Allow as much mellowing time as possible (at least 3 days)
  - Consider adding a second additive such as lime-fly ash or lime-slag
- **> 8000 ppm**:
  - No treatment if swell testing indicates low potential for swell. If material stability is a concern, consider mechanical stabilization
  - Blend low sulfate material with high sulfate soil
  - Remove the existing soil and replace with select fill materials
Questions?

Need more information?
http://www.dot.state.tx.us/cst/technical_advisories.htm

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