Soil Stabilization for Pavements

Course Number: GE-02-401

PDH: 2

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Module 1: Design Fundamentals

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the specific soil layers and engineering materials eligible for stabilization treatment.
- **Evaluate** the functional differences between soil modification and soil stabilization.
- **Select** appropriate mechanical or additive methods based on project requirements for soil workability and structural strength.

Executive Summary: Soil stabilization and modification provide the engineering criteria for improving structural quality and workability across all pavement layers except surface courses, utilizing mechanical blending or specific chemical and bituminous additives.

Purpose and Scope

This course establishes the technical criteria for enhancing both the **structural quality** and **workability** of soil layers within a pavement system. These criteria apply to the following elements:

- **Base courses** and **subbase courses**.
- **Select materials** and **subgrade layers**.
- All Army pavement construction specifically at **mobilization facilities**.

Key Engineering Definitions

To ensure consistent application of these standards, the following definitions are established:

- **Soils**: Naturally occurring materials used for all pavement construction layers **excluding the surface layers**. These materials are subject to classification tests to determine engineering characteristics under **MIL-STD-619**.
- **Stabilization**: The technical process of blending materials to improve pertinent soil properties. This includes altering gradations or using additives to act as a **binder for cementation**.
- **Modification**: A specific stabilization process intended to improve soil properties (such as workability) **without** designing for a significant increase in inherent strength or durability.
- **Additive**: A manufactured commercial product integrated into the soil to enhance layer quality. This course strictly limits additives to:
    - **Portland cement**.
    - **Lime**.
    - **Lime-cement-fly ash (LCF)**.
    - **Bitumen**.

⚠️ **Safety Constraint**: All soil characteristics must be evaluated using the classification system described in MIL-STD-619 to ensure design accuracy.

Primary Methods of Stabilization

The effectiveness of any stabilization effort is directly dependent on achieving **uniformity** during the blending process.

Mechanical Stabilization

This method involves the physical mixing of soils with two or more gradations to meet required specifications.

- **Location**: Blending may occur at the construction site, a central plant, or a designated borrow area.
- **Placement**: Once blended, materials are spread and **compacted to required densities** using conventional equipment.

Additive Stabilization

Additive methods are categorized into two technical types:

1. **Chemical Stabilization**: Integration of cement, lime, fly ash, or combinations thereof.
2. **Bituminous Stabilization**: Addition of specific percentages of bituminous material.

💡 **Design Tip**: The required percentage of an additive depends heavily on your goal. Smaller amounts are typically sufficient for altering **workability and plasticity**, while higher concentrations are necessary if the goal is to **permit a thickness reduction design** by significantly increasing strength.

Mixing Requirements

While various equipment can be used, engineering preference follows this hierarchy:

- **Preferred**: Stationary or traveling plants (for maximum uniformity).
- **Acceptable**: Rotary mixers, graders, disks, plows, or scarifiers.

Checkpoint Quiz

1. **Which of the following describes "Modification" as defined in this module?**
   a) A process that results in a significant increase in soil durability.
   b) A process intended to improve soil properties without a designed increase in strength.
   c) The blending of soils solely to achieve a desired gradation.
   d) The use of bitumen to act as a binder for cementation.

Answer: (b). Modification focuses on workability or property improvement rather than structural load-bearing increases.

2. **When is additive stabilization used to permit a "thickness reduction design"?**
   a) When only the plasticity index needs to be reduced.
   b) When additives are used primarily to improve soil workability.
   c) When strength and durability are improved sufficiently through higher additive percentages.
   d) When mechanical blending is performed at a central plant.

Answer: (c). Significant structural improvements allow for thinner pavement layers, whereas smaller amounts only modify basic properties.

Module 2: Design Objectives and Stabilizer Selection

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** soil layers based on performance requirements, including shear resistance and deflection limits.
- **Select** the optimal stabilizing additive by utilizing the soil gradation triangle and classification restrictions.
- **Determine** appropriate construction cutoff dates for frost-susceptible regions based on ambient temperature and curing rates.

Executive Summary: Stabilization enhances the ability of soil layers to distribute loads over greater areas, which may permit a reduction in required layer thickness provided minimum unconfined compressive strength and durability standards are met.

Functional Uses of Stabilization

Effective pavement design requires that every soil layer achieves specified quality levels to maintain structural integrity. Each layer must satisfy three primary performance criteria:

- **Shear Resistance**: Resisting internal shearing forces within the layer.
- **Deflection Control**: Avoiding excessive elastic deflections that cause fatigue cracking in surface or overlying layers.
- **Deformation Prevention**: Preventing permanent deformation caused by further densification.

Quality Improvement vs. Thickness Reduction

Stabilization serves two distinct design roles:

1. **Soil Modification (Quality Improvement)**: Focuses on better gradation, reducing plasticity or swelling potential, and providing all-weather working platforms.
2. **Thickness Reduction**: Enhances tensile strength and stiffness sufficiently to reduce the required thickness of the stabilized and overlying layers.

⚠️ **Safety Constraint**: To permit a thickness reduction in design, the material must meet specific durability requirements and the minimum unconfined compressive strength standards shown in Table 2-1.

Table 2-1. Minimum Unconfined Compressive Strengths for Cement, Lime, and Combined Lime-Cement-Fly Ash Stabilized Soils

	Minimum Unconfined Compressive Strength (in psi)	
Stabilized Soil Layer	**Flexible Pavement (psi)**	**Rigid Pavement (psi)**
Base course	750	500
Subbase course, select material or subgrade	250	200

Where:

- **psi** = pounds per square inch
- **Note a**: Strength is determined at 7 days for cement, and 7 or 28 days for lime/LCF.

Selection of Stabilizer Additive

Selecting the correct additive requires evaluating soil type, project purpose, strength needs, and environmental conditions.

The Gradation Triangle Method

The **Gradation Triangle** (Figure 2-1) identifies the suitable additive area based on three percentages:

- **Gravel**: Material retained on the No. 4 sieve.
- **Sand**: Material passing the No. 4 sieve but retained on the No. 200 sieve.
- **Fines**: Material passing the No. 200 sieve.

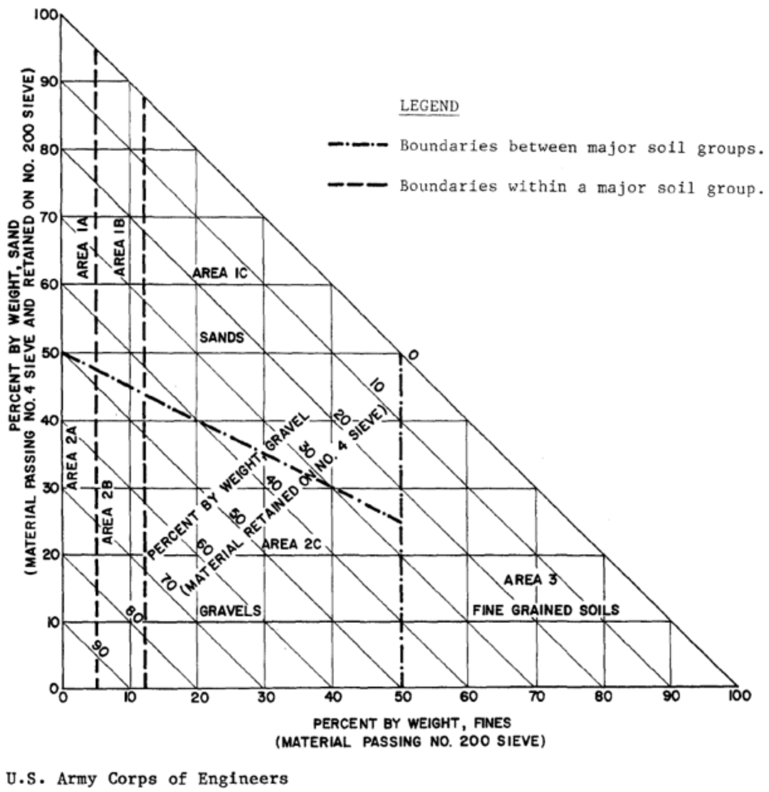

Figure 2-1. Gradation Triangle for Aid in Selecting a Commercial Stabilizing Agent

Application of Selection Criteria

Once the soil area (e.g., 1A, 2B, 3) is determined from Figure 2-1, use Table 2-2 to select the additive considering Liquid Limit (LL) and Plasticity Index (PI) restrictions.