# Chapter 5: Stabilized Soil and Pavement Materials

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## Introduction

In highway engineering, the quality of subgrade and pavement materials is critical for ensuring long-lasting and cost-effective road construction. Natural soils often lack the necessary strength and durability required to serve as reliable foundation layers under varying traffic and environmental conditions. Soil stabilization is an essential technique used to enhance the engineering properties of weak soils. Similarly, pavement materials—especially stabilized ones—play a crucial role in both flexible and rigid pavement systems. This chapter explores in detail the principles, types, techniques, and evaluation methods of soil and pavement material stabilization.

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## 5.1 Soil Stabilization – Fundamentals

### 5.1.1 Definition and Objective

Soil stabilization refers to the process of altering soil properties to improve its strength, durability, and load-bearing capacity. The main objective is to make the soil suitable for construction by enhancing its mechanical behavior.

### 5.1.2 Need for Soil Stabilization

- Weak or unsuitable soil conditions.
- To reduce pavement thickness.
- To minimize maintenance costs.
- Improve resistance to water and erosion.
- Increase shear strength and bearing capacity.

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## 5.2 Types of Soil Stabilization Techniques

### 5.2.1 Mechanical Stabilization

Involves blending different soil types or adding granular materials to improve gradation and compaction characteristics.

- Tools Used: Compactors, rollers, graders.
- Applications: Embankments, subgrade preparation.

### 5.2.2 Chemical Stabilization

Involves mixing chemical additives that react with soil particles to improve binding and reduce plasticity.

#### a) Lime Stabilization

- Used for clayey soils.
- Improves plasticity index and reduces swelling.
- Forms cementitious compounds (calcium silicate hydrates).

#### b) Cement Stabilization

- Adds compressive strength.
- Suitable for sandy and gravelly soils.
- Reactions: hydration of cement and pozzolanic reaction.

#### c) Fly Ash Stabilization

- By-product of thermal power plants.
- Pozzolanic in nature; reacts with lime and water.
- Improves strength over time.

#### d) Bituminous Stabilization

- Used to waterproof soil.
- Reduces moisture sensitivity.
- Suitable for granular soils.

### 5.2.3 Thermal Stabilization

- Involves heating or freezing soil to change its properties.
- Rarely used in highway construction due to high cost.

### 5.2.4 Electrical Stabilization

- Electro-osmosis technique for silty and clayey soils.
- Effective in dewatering and strengthening soils.

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## 5.3 Stabilization Using Geosynthetics

- **Geotextiles, geogrids, and geomembranes** are used to reinforce, filter, or separate soil layers.
- Benefits:
  - Increase bearing capacity.
  - Reduce differential settlement.

- Improve slope stability.

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## 5.4 Factors Affecting Soil Stabilization

- Soil type and gradation.
- Moisture content and plasticity.
- Type and quantity of stabilizing agent.
- Environmental conditions.
- Compaction effort and technique.

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## 5.5 Design of Stabilized Soil Mixes

### 5.5.1 Laboratory Tests

- Unconfined Compressive Strength (UCS)
- California Bearing Ratio (CBR)
- Plasticity Index (PI)
- Proctor Compaction Test

### 5.5.2 Field Performance Tests

- Plate load test
- Field CBR
- Density and moisture content monitoring

### 5.5.3 Mix Design Guidelines

- IRC, ASTM, and AASHTO standards
- Establish optimum binder content
- Target strength and durability requirements

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## 5.6 Pavement Materials and Their Stabilization

### 5.6.1 Introduction to Pavement Materials

- Subgrade soil
- Granular sub-base (GSB)
- Water Bound Macadam (WBM)
- Wet Mix Macadam (WMM)
- Bituminous and cementitious layers

### 5.6.2 Stabilized Sub-base and Base Layers

- Use of cement, lime, and fly ash for GSB and WMM.
- Benefits:
  - Reduced thickness of pavement.
  - Improved load distribution.
  - Higher resistance to water damage.

### 5.6.3 Stabilized Bituminous Layers

- Dense Bituminous Macadam (DBM)
- Bituminous Concrete (BC)
- Use of additives like polymers, rubber, and nano-materials.

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## 5.7 Stabilized Materials for Rigid Pavements

- Sub-base often treated with cement or fly ash.
- Prevents pumping and erosion.
- Enhances slab support and longevity.

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## 5.8 Performance Evaluation of Stabilized Materials

### 5.8.1 Durability Tests

- Wet-Dry Cycling
- Freeze-Thaw Cycling

### 5.8.2 Strength Tests

- Indirect tensile strength (ITS)
- Modulus of Elasticity
- Triaxial Shear Test

### 5.8.3 Moisture Susceptibility

- Modified Lottman Test
- Permeability tests

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## 5.9 Stabilization Equipment and Construction Techniques

### 5.9.1 Equipment Used

- Pulverizers

- Graders
- Rotary mixers
- Water trucks and distributors
- Compaction rollers

### 5.9.2 Construction Steps

1. Site preparation.
2. Pulverization of existing soil.
3. Addition of stabilizer.
4. Mixing and blending.
5. Moisture adjustment.
6. Compaction.
7. Curing (if cementitious).

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## 5.10 Environmental and Economic Considerations

- Use of industrial by-products (e.g., fly ash, GGBS).
- Reduction in natural aggregate consumption.
- Carbon footprint reduction.
- Life-cycle cost analysis.

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