



LIME TREATMENT IN GEOTECHNICAL ENGINEERING:

Terms, Tests & Applications

COMMON TERMS & ACRONYMS

Soil Properties

- **Plasticity Index (PI):** The numerical range between liquid and plastic limits; indicates soil's plasticity.
 - $PI = LL - PL$
 - PI indicates the range of moisture content over which soil exhibits plastic behavior. Higher PI means greater plasticity (common in clays), while lower PI suggests less plasticity (silty or sandy soils).
- **Liquid Limit (LL):** Water content where soil changes from plastic to liquid behavior. It reflects the soil's ability to retain water and is critical for classifying fine-grained soils.
- **Plastic Limit (PL):** Moisture content where soil begins to behave like a plastic, meaning it can be molded without cracking. Below PL, the soil is brittle and crumbly.

Strength & Load Tests

- **California Bearing Ratio (CBR):** Measure of soil's load-bearing capacity compared to a crushed stone standard. CBR of 5% means soil is 5% as strong as crushed stone.
 - Poor Subgrade (clays, silts): $CBR < 5\%$ → Requires stabilization or thick pavement layers.
 - Fair Subgrade: $CBR 5-10\%$ → Suitable for light traffic with proper pavement design.
 - Good Subgrade (well-compacted granular soils): $CBR 10-20\%$ → Adequate for most highway applications.
 - Excellent Subgrade (crushed stone or high-quality gravel): $CBR > 20\%$ → Ideal for heavy traffic and minimal pavement thickness.

OVERVIEW & KEY TERMS

PURPOSE OF LIME IN GEOTECHNICAL WORK



- **Drying** wet soils to achieve compaction, improve construction access and reduce delays.



- **Modifying** plasticity and workability for easier handling & compaction, as well as improved engineering properties.



- **Stabilizing** soils to enhance long-term strength, durability, and load-bearing capacity.

- **Unconfined Compressive Strength (UCS):** Maximum axial stress soil can withstand without lateral support. The greatest force, pushing from the top, that the soil can take without help from the sides.

Compaction Characteristics

- **Maximum Dry Density (MDD):** Highest dry density achievable through compaction.
- **Optimum Moisture Content (OMC):** Moisture level for achieving MDD during compaction.

Construction Techniques

- **Engineered Backfill Soil (EBS):** Soil designed and placed to meet specific structural criteria. (i.e. PI, gradation, minimum UCS or CBR)
- **Full Depth Reclamation (FDR):** Process of recycling existing pavement, base, and subgrade into a stabilized layer using reagents like cement or lime to create a strong, stabilized foundation for new pavement.

TESTS & INTERPRETATION

Lab Tests

- **Atterberg Limits**
Definition: Measures the moisture content at which soil changes between solid, plastic, and liquid states.
Use: Helps classify fine-grained soils and assess how they'll behave when dried or stabilized.
- **Lime Series**
Definition: A lime series is a set of lab tests where soil samples are mixed with different percentages of lime (e.g., 2%, 4%, 6%, 8%) and evaluated for strength and performance.
Use: Identifies the optimum lime content that provides the best improvement in soil properties to satisfy project goals.
- **Eades-Grim pH Test**
Definition: A standardized lab test to evaluate the minimum lime content required to stabilize clay soils by achieving a pH of 12.4.
Use: Ensures long-term strength and durability of lime-treated soils.
- **Strength Gain (UCS over time)**
Definition: Tracks the increase in Unconfined Compressive Strength (UCS) of treated soil over days or weeks.
Use: Verifies the effectiveness of stabilization and predicts performance under load.



CBR TESTING



ATTERBERG LIMITS TESTING



SOIL SAMPLES DRYING IN OVEN



SOIL SAMPLES AFTER DRYING

Field Tests

Dynamic Cone Penetrometer (DCP)

Definition: Measures the resistance of soil to penetration by driving a cone into the ground with a standard weight drop.

Use: Evaluates soil strength and stiffness, commonly used to monitor improvement after lime or cement treatment.

Plate Load Test

Definition: A field test where a steel plate is loaded incrementally to measure soil bearing capacity and settlement.

Use: Assesses the load-bearing behavior of stabilized soil layers, especially for pavement or foundation support.

Falling Weight Deflectometer (FWD)

Definition: A non-destructive device that drops a known weight on pavement to measure deflection and assess structural capacity.

Use: Determines pavement strength and helps design maintenance or rehabilitation strategies by assessing load-bearing performance.

Moisture Testing

Definition: Determines the percentage of water in the soil using methods like a nuclear gauge, burn-off test, or a Speedy Moisture Gauge.

Use: Confirms soil moisture (before and after lime application) to evaluate compaction targets, drying effectiveness and improved workability.

Speedy Moisture Gauge

Definition: A portable device that measures soil moisture by reacting the sample with calcium carbide and reading the resulting gas pressure.

Use: Offers quick field moisture checks for compaction control and material preparation.

Oven-Dry Method

Definition: Measures **soil moisture** by drying a sample in an oven to a constant weight.

Nuke Gauges (Nuclear Gauge)

Definition: Measure **soil density and moisture** in the field using radiation.

Use for Both Tests: Provides moisture content for assessing soil compaction and material behavior.

Geotechnical Testing In Action



OPTIMIZING LIME PERFORMANCE



Mellow Period: A mellow period affects both strength gain (stabilization) and plasticity reduction (modification), but each responds on a different timeline. For stabilization, a shorter mellow period with proper hydration and mixing often improves strength. For PI reduction through modification, a longer mellow period can help, though anything beyond about 24 hours is rarely needed.



Lime Type (Quicklime vs Hydrated Lime): Quicklime (CaO) reacts exothermically with water, while hydrated lime (Ca(OH)_2) is already water-reacted.

Why it matters: Quicklime reacts rapidly with moisture and can enhance drying, while hydrated lime offers minimal drying. Both quicklime and hydrated lime deliver the calcium component needed for modification and stabilization.



Cure Period: This refers to how long lime-treated soil is allowed to react and cure under specific moisture and temperature conditions.

Why it matters: Proper curing ensures full chemical stabilization, leading to increased strength, reduced plasticity, and long-term durability.

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BEFORE STABILIZATION



6% APPLICATION



AFTER STABILIZATION

*According to 3rd party test results. Results may vary based on soil type and ambient conditions.