LIME IN SOIL

Chemical Lime
A Lhoist Group Company

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Cost-effective construction alternatives that ease work schedules and expand design options.

What is soil?

Soil describes the loose mix of mineral and organic materials generally found between the earth's surface and solid bedrock. Its chemical and physical properties vary significantly from one location to another. Soil supports most man-made structures and is the oldest building material.

Soil is often too wet, weak, or expansive to be used in constructive operations without treatment. Clay bearing soils can be damaging to structures and bog down construction. Silty or sandy soils may not gain adequate strength under compaction. These conditions can be remedied with the addition of lime or lime and fly ash. Lime is a general term including quicklime (CaO), hydrated lime (Ca(OH)2), and lime slurry (hydrated lime in water).

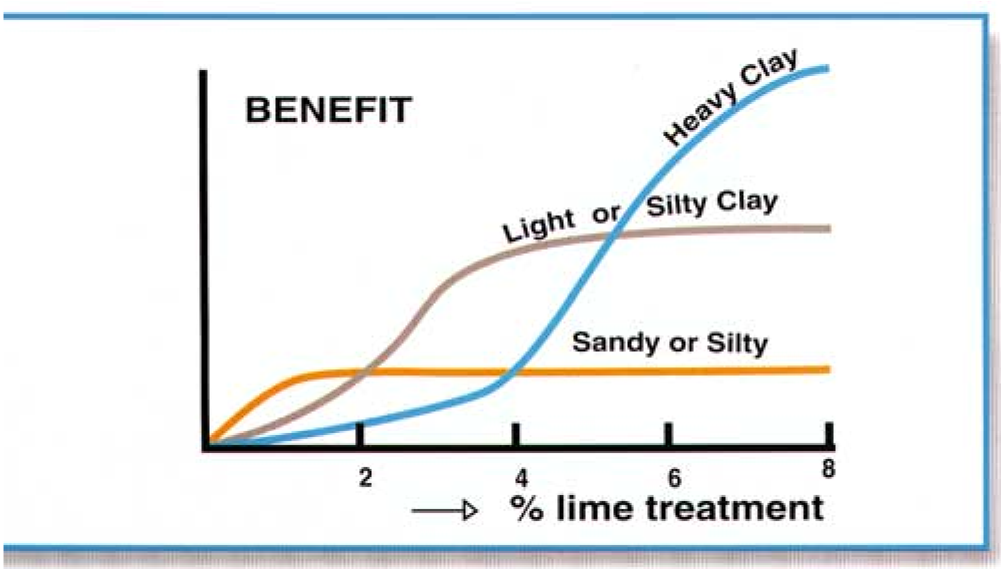
Soil properties can be tailored to specific construction applications with the addition of lime. Quicklime draws water out of mud and reacts with it, drying soil. In clay-bearing soils, lime induces a textural change resulting in greater ease of compaction and handling as well as moderate improvements in the resulting strength. This process is typically called modification. If sufficient lime is applied to the soil under the right conditions, a pozzolanic reaction ensues, forming permanent cementitious products. This is the process of soil stabilization. Lime-soil mixtures can be readily prepared to meet either need.

Drying

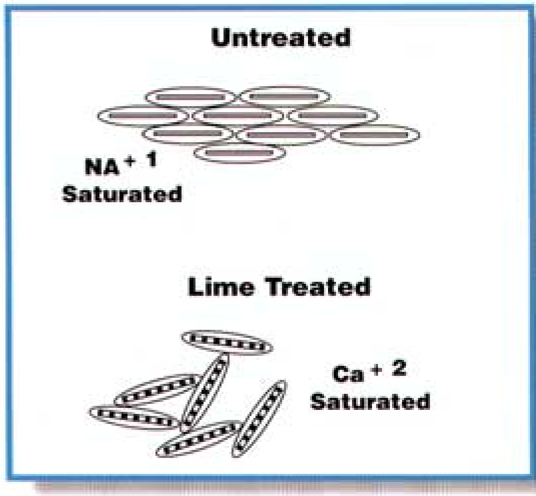
Quicklime reacts with water to produce hydrated lime, using up water at the rate of 30% by weight. This water is drawn out of wet, boggy mud and thus dries the soil significantly. Additionally, the lime provides a source of dry solids to further reduce moisture content. In clays, the resulting hydrated lime may perform some soil modification, enhancing the moisture-holding capabilities of the natural soil. Silty or sandy soils can be dried rapidly with minimal mixing.

Soil Modification

Modifying clay soil with lime reduces plasticity and potential for volume change, improves workability and compaction, and improves immediate shear strength. These textural and manageability enhancements are typically associated with cation exchange within the clay minerals and the flocculation and agglomeration of the treated particles. Light clays and



Lime can improve soil texture and strength as well as handle excess moisture.



Lime treatment transforms unstable, water-sensitive formations of clay minerals into more stable microstructures through cation exchange and flocculation.

silty soils can also benefit with improvements in shear strength.

In the natural state, clay particles have tremendous surface area. Three grams of some clays have the same surface area as a football field. This surface area, due to its particularly charged chemical composition, has a weak buffer zone of ions like sodium. Instability in these zones allows clay to draw enormous amounts of water around particles. This ability to soak up water drives destructive swelling and strength loss in clay layers.

The drawing power of the clay mineral is relieved by the creation of a stable calcium ion buffer in the inter-layer regions of the clay layers. A calcium buffer satisfies the demands of the clay mineral surface and equalizes the conditions that permit expansion and weakening.

The water layer the clay minerals can support shrinks due to the calcium ion buffer. As a result, the particles can come into contact with one another. This coming together is called flocculation and is directly responsible for the textural change. With this textural change, clays with a high plasticity index (PI) are almost instantly transformed into workable, low-PI or non-plastic materials.

Cation exchange in expansive clays is driven by the availability of calcium. All other things being equal, the more expansive the clays, the more calcium required. As lime is a superior source of active calcium, it is the solid choice for the reduction of plastic clays.

The level of modification is typically selected with target values for the PI, swell potential, or bearing capacity. Soil modification with lime effectively shrinks construction times and facilitates the movement of people and machinery. Modification is not a permanent effect under all conditions.

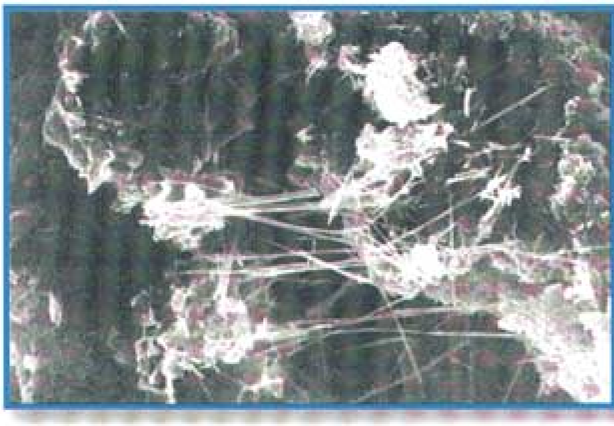
Soil Stabilization

Stabilization is classified as the development of permanent strength in the placed soil-lime mixture. This strength development results from a pozzolanic reaction between the lime introduced into the soil system and the available pozzolans. Clay minerals are pozzolans, containing large amounts of the necessary silicates and aluminates. As lime reacts directly with the clay minerals in an alkaline (high pH) condition, it breaks them down and incorporates them in a cementitious product. This reaction eliminates expansive potential permanently. Cement reacts with itself rather than with the clay and therefore does not reduce expansive potential as well as lime.

Lime stabilization can be accomplished in soils with little or no clay content through the addition of fly ash. Fly ashes are also pozzolans that can drive the reaction in sandy or silty soils with little or no clay.

The strength-gaining pozzolanic reaction requires high alkalinity (pH of 12.3) and sufficient water to be

This electron micrograph of a clay mineral shows the multiple sheet formation that gives clays their tremendous surface area and a great affinity for water.



After lime treatment, rod-like projections form in the clay sheets. These are hydration products common to concretes and are formed by the breakdown of the clay by pozzolanic reaction.

effective. This highly alkaline environment facilitates the attack of the clay mineral and ensures the availability of lime to drive the long-term pozzolanic reaction. Promoting the breakdown of clay minerals through the pozzolanic action ensures long-term strength gain and performance. A pH test with the soil and lime is a valuable and necessary design tool for these applications.

Adequately stabilized soils contribute significant support to structural designs placed above them. The gentler curing of lime processes also ensures greater working time and potentially less cracking due to excessive shrinkage or rigidity. Lime stabilization also confers protection to the overlying structure from destructive seasonal moisture or freeze cycles.

Customization

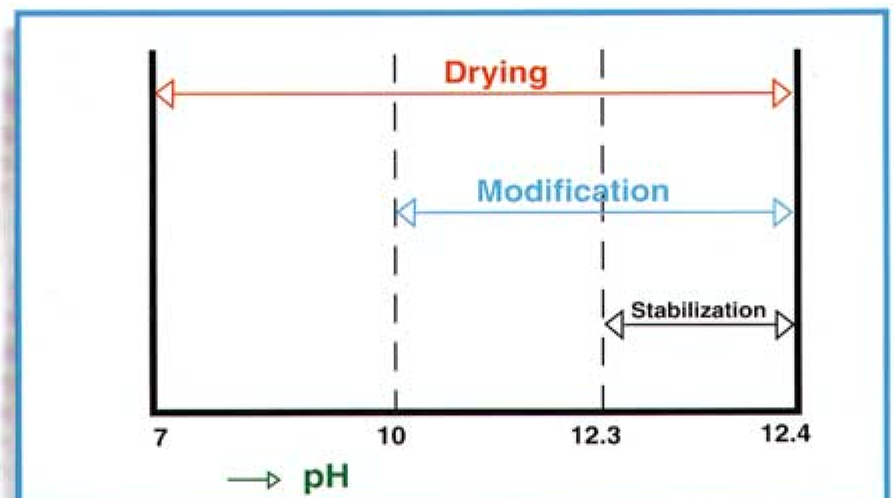
Allowing lime to manage the pH of the stabilized or modified layer to suit the needs of its application unlocks its versatility. A pH test (ASTM C977) can determine what amounts of lime will produce stabilization reactions and what will modify the soil without significant pozzolanic activity. If modification is desired, a PI series or other testing can then optimize the lime content necessary. Should stabilization be required, design-level strength testing is greatly reduced with advance knowledge of the lime content needed to raise pH to acceptable levels. Either way, the pH test is a rapid, inexpensive way to ascertain the demand for lime within the soil.

For further information, please consult the *Handbook for Stabilization of Pavement Subgrades and Base Courses with Lime*, Dr. Dallas Little, Texas A&M University. (Kendall/Hunt Publishing Company, ISBN 0-8403-9632-5).

Chemical Lime Company is North America's leading producer and supplier of solutions-oriented, lime-based products for industrial, municipal, and environmental applications. CLC, headquartered in Fort Worth, Texas, has more than 46 locations in North America. CLC is a member of the Lhoist Group, Brussels, Belgium.

For more information, contact your Chemical Lime Company representative or call 1-800-365-6724 (eastern U.S.) or 1-800-978-0325 (western U.S.) or write to the address below.

"Soil Stabilization #102, Sept. 2000"



The necessary lime application rate can be determined with a simple pH test.

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