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**LESSONS LEARNED:**
**Geotechnical Engineering**
OBSERVATIONS AND LESSONS FROM THE SCHOOL OF EXPERIENCE

# SOIL IMPROVEMENT USING LIME

The application of lime to predominantly fine-grained soils can be used to: dry high moisture content soils; reduce the shrink/swell potential of high plasticity soils; and stabilize certain soft soils. Like any other product or procedure, lime can be of significant benefit if applied correctly. If misapplied, significant problems can occur. The purpose of this Lessons Learned is to describe the uses and benefits of lime application, and the proper procedures and precautions that should be taken when applying lime.

**WHAT IS LIME?** There are two non-agricultural types of lime: quicklime and hydrated lime. Quicklime (calcium oxide) is produced by heating the limestone (calcium carbonate) to approximately 900°C (commonly referred to as "burning"), and then grinding it into gravel or sand-sized particles, or a powder. Hydrated lime (calcium hydroxide) is produced by adding a controlled amount of water to quicklime. This process is commonly referred to as "slaking". Because hydrated lime contains chemically bonded water, approximately one third more hydrated lime than quicklime is required to accomplish the intended purposes.

**CHEMICAL DRYING:** Chemical drying consists of applying lime to high moisture content soils to reduce the free (non-chemically bonded) water in the soil so that the soil moisture content is within the optimal moisture content range as determined by the applicable moisture-density (Proctor) test. For drying purposes, approximately 1% to 2% of granular quicklime by dry weight of soil is applied. This amount is not sufficient to accomplish chemical modification or chemical stabilization.

**CHEMICAL MODIFICATION:** Chemical modification typically consists of blending approximately 2% to 4% of granular quicklime by dry weight of soil to high plasticity, expansive soils. The chemical reaction that occurs within the expansive soils causes them to become non-expansive. Chemical modification also dries the soils, and is the most commonly used form of lime treatment where expansive soils are encountered, and is an alternative to removing the high plasticity soils in many cases.

**CHEMICAL STABILIZATION:** Chemical stabilization (stiffening) of soft, wet, fine-grained and/or high plasticity soils can be accomplished by applying approximately 4% to 8% of granular quicklime by dry weight of soil. Chemical stabilization dries the soils, causes expansive soils to become non-expansive, and stiffens the soils. In higher application rates, the soils can become moderately cemented by the addition of lime.

**LABORATORY TESTING:** Laboratory testing of varying quantities of lime mixed with soils obtained from the site is required to determine the amount of lime required to accomplish the intended purpose, whether it be drying, chemical modification, or stabilization. Laboratory tests typically include moisture content tests, Atterberg limits tests for plasticity, grain size analyses, pH tests, soluble sulfate testing for soil acidity, and Expansion Index (EI) testing for shrink-swell potential. Moisture-density tests are developed once the optimum lime content is determined for the intended purpose.

**APPLICATION PROCEDURES:** The most common mistake in the application of lime is inadequate mixing, blending, and mellowing of the soils. Specifically when lime encounters moisture in the soil, the chemical reaction causes heat, steam, and a rapid expansion of the lime to several hundred times its original volume. If there is unreacted lime within the soil, then heaving of the soil surface and structures supported on the lime stabilized soils can occur. Proper mixing typically consists of the application and thorough mixing of the lime into the soil, letting the lime mixture mellow (react with the soils) for approximately 24 to 48 hours, followed by remixing of the soil. Mixing and mellowing of the soil should continue until there are no lime particles visible in the soil. The application of lime is often done by specialty contractors who have machinery specifically designed to properly mix lime into soil.

**APPLICATION PRECAUTIONS:** Unreacted lime is a very strong alkaline chemical that can cause burns and result in damage to surfaces it lands on. The pH of lime is approximately 13 which is at the very upper end of the acid-base pH range. Precautions should be taken during application and mixing of lime to prevent the direct inhalation of lime dust, and lime contact with skin or eyes. In addition, nearby surfaces such as vehicle paint should be protected from contact with lime dust. Good dust control is required during the application and mixing process. Public access to lime stockpiles and soils containing lime during the hydration process, should be prevented. The dust generated from quicklime in populated areas can be difficult to control. Therefore hydrated lime is often used instead of quicklime.

In summary, the incorporation of lime into soils can provide several benefits to earthwork operations. Proper application and mixing procedures are required to achieve the desired benefit. In addition, precautions should be taken to avoid contact with skin, painted surfaces, or inhalation. In some jurisdictions, the use of lime is regulated, so understanding and following the jurisdiction's requirements prior to the application of lime is important. The laboratory testing to determine the required amount of lime is typically performed by your geotechnical engineer. The geotechnical engineer should also observe the process of lime application, blending, remixing, and compaction of lime stabilized soils.

Should you have any questions regarding soil improvement using lime, or any other soils issues, please contact the geotechnical engineering staff at your local ECS office. We hope this Lessons Learned will assist you in your next project, and we wish you continued success in your future endeavors.

Respectfully,
**ECS Corporate Services, LLC**