Types of Soil Stabilization

The three basic types of soil stabilization techniques are (1) Mechanical (2) Compaction & (3) Chemical

1) Mechanical Soil Stabilization Technique:

The oldest types of soil stabilization are mechanical in nature. Mechanical solutions involve physically changing the property of the soil somehow, in order to affect its gradation, solidity, and other characteristics. Ultimately, dense and well graded material can be achieved by mixing and compacting two or more soils of different grades. Addition of a small amount of fine materials such as silts or clays enables binding of the non-cohesive soils which increases strength of the material. On the other hand, strong and angular particles of sand and gravels, impart internal friction and incompressibility to the mix and can be well stabilized with addition of clay owing to its binding properties. Factors affecting the mechanical stability of mixed soil may include:

- The mechanical strength and purity of the constituent materials
- The percentage of materials and its gradation in the mix
- The degree of soil binding taking place
- The mixing, rolling, and compaction procedures adopted in the field
- The environmental and climatic conditions

2) Compaction Soil Stabilization Technique:

Uses mechanical means for expulsion of air voids within the soil mass resulting in soil that can bear load subsequently without further immediate compression. Dynamic compaction is one of the major types of soil stabilization; in this procedure, a heavyweight is dropped repeatedly onto the ground at regular intervals to quite literally pound out deformities and ensure a uniformly packed surface. Vibratory Vibro compaction is another technique that works on similar principles, though it relies on vibration rather than deformation through kinetic force to achieve its goals.

3) Chemical Soil Stabilization Technique:

Chemical solutions are another of the major types of soil stabilization. All of these techniques rely on adding additional material to the soil that will chemically and physically interact with it and change its properties. For example cement stabilization is most effective on low cohesion soils, owing to difficulty in good distribution of the anhydrous stabilizer amongst cohesive clays and because larger granular particles can be surrounded and coated by the cement paste.

On the contrary, in cohesive soils, many particles are smaller than anhydrous cement grains and hence are more difficult to coat. There are a number of different types of soil stabilization that rely on chemical additives of one sort or another; you will frequently encounter compounds that utilize cement, lime, fly ash, or kiln dust. Most of the reactions sought are either cementitious or pozzolanic in nature, depending on the nature of the soil present at the particular site you are investigating. The chemicals present in lime for example are oxides and hydroxides of calcium and magnesium with options for commercial production through calcination of carbonate rock minerals for high calcium limes or as dolomitic limestone consisting of calcium and magnesium oxides through pressure hydration.

Polymer/Alternative Soil Stabilization Technique:

Both of the previous types have been around for hundreds of years, if not more; only in the past several decades has technology opened up new types of soil stabilization for companies to explore. Preference for polycondensation polymers over polyaddition polymers is because the former works with larger polymeric chains, polymerization stops and rarely restarts, and they are low cost and easy to prepare. Synthetic polymers such as vinyls and acrylamides coat soil grains reducing permeability and enhancing the dry strength of the fine material to hold coarser aggregate together. Polymers can be mixed with soil in the form of a liquid in order to fill the pores and harden the soil structure. The prerequisites for polymer stabilization include:

- The polymer must be adhesive to soil particles in the presence of water
- Internal cohesion of the polymer is key
- Workability at high humidity and low ambient temperatures
- Miscibility with water to produce a low viscosity liquid

Most of the newer discoveries and techniques developed thus far are polymer-based in nature, such as those developed by Global Road Technology. These new polymers and substances have a number of significant advantages over traditional mechanical and chemical solutions; they are cheaper and more effective in general than mechanical solutions, and significantly less dangerous for the environment than many chemical solutions tend to be.

All three types are still employed on construction projects all across the globe, though the polymer-based solutions offered by firms like Global Road Technology are rapidly gaining ground due to the cost savings, ease-of-use, environmental benefits, and other significant advantages they bring to the table over more traditional soil stabilization types.

What is Meant by Soil Stabilization?

Soil stabilization is a process by which the physical properties of a soil are transformed to provide permanent strength gains before construction. Stabilized soils outperform non-stabilized soils when materials, design, and construction are properly considered. When the stabilized soil layer is incorporated into the structural design of the pavement, the subsequent layers can be thinner, resulting in sizable cost savings and minimizing the need for virgin materials. In addition to adding strength, stabilized soil forms a solid monolith that decreases permeability, which in turn reduces the shrink/swell potential and the harmful effects of freeze/thaw cycles.

Soil stabilization can improve in situ, or natural state, soils eliminating the need for expensive remove-and-replace operations. Often job sites where roads, building pads, parking lots, runways or other pavement structures need to be built contain naturally wet, weak soils. Those soils can be chemically treated to add strength through stabilization and improve engineering properties including moisture content and plasticity, through modification. Ex situ, or off site, soil stabilization processes are possible but are usually reserved for environmental projects rather than typical construction operations.

hemical Stabilization of Soil

The chemical stabilization of soil is a relatively broad term that is used when chemical reagents such as quicklime, Calciment Lime Kiln Dust (LKD), cement, or other industrial co-products and bi-products are used to increase the strength of subgrade soil. Regardless of the reagent, the use of proper techniques is important. Thorough mixing ensures complete incorporation and an overall homogeneous mix. Moisture and compaction testing is important to be sure that all reactions have occurred. Each reagent must hydrate completely, and maximum density is only achievable at optimum moisture content. Regardless of the stabilizing agent used, pre project planning, including laboratory testing, is important to be certain that the proper amount of stabilizing agent is present to permanently stabilize the soil and provide the desired result.

Soil Stabilization Materials

LIME

Quicklime, often referred to simply as lime, is the chemical compound calcium oxide (CaO). Quicklime is available in two types, high calcium and dolomitic. High calcium is almost completely calcium oxide, whereas dolomitic quicklime contains a portion of magnesium oxide (MgO) along with calcium oxide. Some industrial applications such as steel need the magnesium component for certain processes. For construction purposes, high calcium and dolomitic quicklime are virtually indistinguishable. Learn more about why lime-based products are the most effective soil-drying agent and how they can improve soils through modification.

Lime will stabilize clayey soils to provide long-term, strength gains that will continue after initial application. Studies have shown that these reactions can continue for a year or more. Lime stabilization provides the calcium component and the proper chemical environment that is necessary to permanently stabilize a soil. Since lime is an alkali material, it provides the proper chemical environment by raising the soil pH to the point that naturally occurring pozzolans, such as silica and alumina, to become soluble. Once soluble, they are available to react and form cementitious bonds with the calcium from the lime. The resulting calcium-silicate-hydrates (C-S-H) and calcium-aluminate-hydrates (C-A-H) are permanent and reduce the effect of clay soil resulting in a very resilient subgrade rather than masking it as is the case with other stabilization techniques.

Soils with a plasticity index (PI) of 10 or more are generally great candidates for lime stabilization. Proper laboratory testing is important to determine soil reactivity and dosage rates necessary for proper stabilization.

CALCIMENT® LKD

Lime Kiln Dust, or LKD, is a co-product of the lime manufacturing process that contains a combination of CaO, MgO and pozzolans. Much like fly ash, the pozzolans come from the fuel used in combustion processes and are finely sized materials carried by exhaust gasses and collected by emission controls such as bag houses.

These products are a hybrid of sorts between quicklime and cement that work well in 5-35 PI soils. The presence of pozzolans enables the stabilization of more granular, sandier soils. Since Calciment LKD also contains calcium, like lime, the product can also leverage the pozzolans naturally present in clayey soils to generate cementitious bonds. Similar to fly ash, anytime the co-products are used, energy consumption and emissions are reduced. The use of virgin material and disposal to landfills is minimized, making Calciment LKD an environmentally friendly alternative to traditional reagents.

CEMENT

Cement is a widely used composite material composed mainly of calcium, silica, alumina, and iron derived from limestone, sand and clay. All are processed, fired in a kiln and pulverized to a fine powder. When cement is exposed to water, it chemically hydrates resulting in a gel that forms an interlocking matrix around soil particles. The mix hardens, or cures, very rapidly, typically within one to three hours, so the soil-cement mixture must be placed, mixed and compacted quickly. This rapid curing results in high initial strength gains that taper off rapidly.

Cement is an effective reagent for stabilizing certain types of soils. However, not all soil types are created equal and understanding the geotechnical properties of the soils for your specific application is key. Cement is a good option when working with sandy, coarse-grained soils but the effectiveness of cement decreases as clay content and plasticity increase. Cement stabilization merely masks the effect of clay and is not an economical option to stabilize fine-grained soils. Additionally, undesirable shrinkage cracking is often associated with cement-stabilized soils allowing water to penetrate and cause further damage.

Soils with a plasticity index (PI) of 10 or less are generally candidates for cement stabilization. Proper laboratory testing is important to determine the right product, and dosage rates necessary to properly stabilize the soil for your specific application.

Other Stabilization Products

BITUMEN

Bitumen is a naturally occurring organic binder that is typically obtained from petroleum distillation or refining crude oil. It is a sticky, viscous liquid that commonly holds asphalt together. When bitumen is added to a soil, it fills the voids in the soil to mechanically stabilize the soil rather than reacting with individual soil particles. Soil type is an important factor when considering bitumen for stabilization. Finely grained soils need higher dosage rates of bitumen to stabilize soil compared to sandy, coarse-grained soils. Bitumen is often one of the costliest construction materials, so dosage rates are a key factor for cost effectiveness when considering bitumen. Weather is another factor to consider as bitumen and its viscosity is very susceptible to differences in temperature. Viscosity will decrease with temperature resulting in poor mixing, an unwanted uneven mix and seemingly random stabilization in colder temperatures.

GEOTEXTILES

Geotextiles are fabrics that resist chemicals and biodegradation. Like bitumen, geotextiles mechanically interact with the soil to provide increased strength and bearing capacity. Opening size, interlocking grab strength, and puncture resistance are important factors associated with geotextiles. The increased cost of geotextiles adds to the overall cost of the project.

GROUT

Grout is a flow-able mixture of water, cement and sand that can be pumped throughout a jobsite. Slurried grout is injected at predetermined intervals to infiltrate the soil matrix. The mix cures over time adding strength and bearing capacity to the soil. Pressure grouting is only an option in granular soils as the material must be able to flow through the mass of soil. The fine particle size associated with clayey soils results in minimal to no permeation, rendering grouting ineffective.

Soil Stabilization Methods

LAB TESTING

Laboratory testing is important to determine the product type and minimum dosage rate as well as the water necessary to reach optimum moisture content. Our Innovation Center and Customer Application Specialists are available to prove out options.

TRANSPORTATION AND SPREADING

Lime typically arrives at the jobsite via pneumatic truck before being transferred into a spreader truck. Spreader trucks distribute the material on the job site at the specified dose rate. Once the chemical reagent is applied, water is usually added, and the amount is dependent on the desired results and current water content of the soil. For smaller or remote jobs, lime can be delivered in dump trucks or bulk bags.

Pneumatic Truck

Bulk Bags

MIXING

The lime and water need to be properly incorporated into the soil to achieve a homogeneous mix and help break down the soil. Reclaimers are the preferred mixing equipment for this portion of the process. However, backhoes and bulldozers work well for smaller jobs or when the initial soil bearing capacity is low, which is often the case on environmental sites involving lagoon, sludge or sediment stabilization projects.

COMPACTION AND GRADING

Both compaction and grading are important to allow free water to drain to keep the integrity of the stabilized soil. Compaction, targeting maximum dry density, can be achieved by using a number of different soil compaction methods. The compacted material is then graded to a profile and cross slope. Finally, the surface is ready for a final smooth roll to seal the soil making the subgrade ready for further construction to continue.

Step by step process

STEP 1:

Lime is transferred from Pneumatic truck to spreader truck

STEP 2:

Mintek's reagent, water and soil are mixed using a reclaimer

STEP 3:

A spreader truck then spreads product over the problematic soil

STEP 4:

A drum roller or pad foot compacts the pulverized mix

Soil Stabilization Using Cement

Cement stabilization is very similar to lime stabilization but the cement must be placed, mixed and compacted before the mix starts to cure, generally within three hours. If there is a disruption in production, reapplication and incorporation may be necessary.