


Soil Stabilization

EJB Pavement Preservation

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is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a subgrade to support pavements and foundations. Soil Stabilization is performed in much the same manner as Full Depth Reclamation. A reclaiming machine first pulverizes the soil material in question. An additive is then placed on top of this material. This additive is mixed and re-mixed with the soil until the desired properties are achieved. This process can vary depending on the soils and additives required. Soil Stabilization can be utilized on roadways, parking lots, site development projects, and in many other situations where subsoils are not suitable for construction.

Stabilization can be used to treat a wide range of subgrade materials, varying from expansive clays to ranular materials. This process is accomplished using a wide variety of additives, including lime, fly-ash, and Portland cement. Other material byproducts used in Stabilization include lime-kiln dust (LKD) and cement-kiln dust (CKD). Proper design and testing is an important component of any stabilization project. This testing will establish proper design criteria in determining the proper additive and admixture rate to be used to achieve the desired engineering properties.

Another form of soil treatment closely related to Soil Stabilization is Soil Modification (sometimes referred to as "mud drying" or soil conditioning). Although some stabilization inherently occurs in Soil Modification, the distinction between the two is that Soil Modification is merely a means to reduce the moisture content of a soil to expedite construction. Alternatively Soil Stabilization can substantially increase the shear strength of a material such that it can be incorporated into the project's structural design. The determining factors associated with Soil Modification versus Soil Stabilization may be the existing moisture content, the end use of the soil structure, and ultimately the cost benefit provided.

Mixing and Placement

The first step in the Stabilization process is to pulverize the material being treated with a Soil Stabilizing machine, commonly referred to as a reclaimer. An additive must then be introduced to the pulverized material. The choice of what additive to use in the process is determined through testing done prior to the start of stabilization. How an additive is placed depends on which one is utilized. For example, if an asphalt emulsion is used, the reclaimer will pulverize the soil a second time while simultaneously injecting the emulsion into the soil through computer-controlled spray units attached to the reclaimer. If a slurry mix is used, the slurry can be introduced in the same manner as the asphalt emulsion or can be metered from tankers directly into the soil being stabilized. When using slurry material, temporary reservoirs may need to be built to hold the liquid slurry mix in place in front of the reclaimer until it is incorporated into the soil.

Additional pulverization or mixing passes may be necessary to obtain the required gradation or to increase uniformity. During the initial pass of the reclaimer, compaction may occur beneath the wheels of the reclaimer. This can cause surface irregularities and a discrepancy in the depth of previously treated material. To better assist in accurately controlling mixing depths in subsequent passes by the reclaimer, previously treated material should be graded and lightly compacted prior to additional mixing passes.

Many modern reclaimers will place the pulverized and mixed materials in different ways. Most often, the cutting tools on the reclaimer cutting drum are arranged in a chevron pattern to promote mixing. Lateral movement of most reclaimed material is minimal. The reclaimed material exits from the pulverization/mixing chamber rear door and is spread across the width of the pass being made. The material is then struck off and smoothed out by the bottom edge of the rear door.

A motor grader is used to move and place the treated material to the desired grade and slope. The amount of grader work required to place the processed material will depend on the original contour or shape of the area. It will also depend on what pavement cross-section is being used on top of the stabilized area.

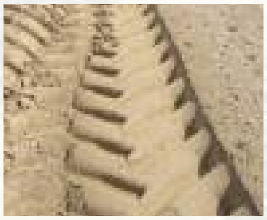
The compaction achieved during this process is one of the primary determinants of the future performance of the stabilized mix. Stabilized mixes which are poorly compacted:

- can densify under traffic, resulting in surface rutting
- will not achieve early strength gain which can result in surface raveling
- will not achieve the ultimate strength gain, possibly leading to premature failures

Obviously, it is critically important the adequate compaction be achieved during construction. Typically, one or more compactors are needed to adequately densify the stabilized mix. As with compaction of other materials, the size, type, and quantity of compactors will be dependent on the material properties, lift thickness, percent compaction required, smoothness desired, and other production requirements. The characteristics of the stabilized mix will determine whether padfoot, smooth drum and/or pneumatic compactors should be used. The depth and degree of compaction will influence the weight, amplitude/frequency of vibration, and other compactor requirements. A field test strip can be implemented to determine the best compaction practices to be used in achieving the desired results.

Stabilization can be accomplished using a wide variety of additives. The following are some of the more commonplace additives and procedures used:

Soil Cement



Soil Cement is a mixture of pulverized soil material and measured amounts of Portland cement and water. Portland cement is a very fine hydraulic binder in powder form. It primarily consists of calcified lime compounds, mixed with silica, alumina, and iron oxide. When mixed with water, it will harden both in air and under water.

One of the oldest concepts of Soil Stabilization is known as "Soil Cement." The process was introduced many years ago and is very basic and economical. Another name used for this process is cement stabilized aggregate base. Samples are taken from the proposed site and tested in a laboratory to determine



the existing soil properties. Based on design and loading criteria, the amount of cement required to achieve the desired compressive (load bearing) strength is then calculated. From this, an application rate for the cement and water is determined.

Once on site, a motor grader or dozer removes vegetation and topsoil. A reclaimer pulverizes the existing material. The Portland cement is then placed by a spreader using the application rate specified. The reclaimer then thoroughly mixes the cement with the soil. Water is added throughout this process as prescribed by the mix design. The processed material

Country Club Road, Limerick Township, Before Lime Stabilization…

is graded to the proper slope and compaction is completed per project specifications.

While the material is curing, a prime coat of diluted emulsified asphalt is placed on the surface. This will protect the surface, keep dust to a minimum, and slow the curing process.

Portland cement, when used as a binder, can result in the highest possible load bearing capacity in comparison to other binders. It can be used to bind non-cohesive materials such as gravel, sand, aggregate, or reclaimed asphalt. It can also be used to bind local granular materials such as slag, limerock, and scoria. Cement has been used to treat silt and clay, however, thorough engineering and design analysis are required prior to utilizing it in that manner.

Soil Cement is a hardened material which contains sufficient cement to satisfy established weight-loss criteria based on standard freeze-thaw and wet-dry tests. Adding relatively small amounts of Portland cement and water to a relatively poor soil can drastically improve the chemical and physical properties of the soil. The material plasticity and volume-change capacity can be reduced and the bearing value increased.

Lime

The use of lime in Soil Stabilization is one of the most rapidly growing practices being used today. Soil Stabilization utilizing lime as an additive is especially effective when dealing with clay-bearing soils and aggregates.

The word "lime" is a most general term and is frequently misused. In the context of Soil Stabilization, lime refers to either quicklime (calcium oxide) or hydrated lime (calcium hydroxide). Both of these are burned forms of limestone (calcium carbonate). Stabilization involving lime refers to only burned lime products, not pulverized limestone.

For use in Stabilization, lime may be applied in a powder form or in a slurry (a water and lime mixture). The chemical reaction that occurs when lime is introduced to clay-type soils is two-fold:

- It reacts with fine clay particles to produce coarse friable particles through a phenomenon known as "base exchange."
- It produces a cementing or hardening action. The lime reacts with the available silica (sand) to produce a very strong and stabilized layer.

The Completed Roadway.

Lime reacts favorably with soils that have a high Plasticity Index (PI). The high PI range can vary from 10 to 90%. The use of lime as an additive in Soil Stabilization will:

- normally drop the PI in the soil to below 10%.
- lower the required binder content considerably.
- increase the workability of the soil.
- aid in drying out wet soils quickly. Compaction can usually be accomplished sooner and more effectively.
- reduce shrinkage and swelling.

After curing, the compressive (load bearing) strength of the soil is increased greatly over the original capability. This is established using a variety of tests such as CBR, R-value, K-value, etc. The tensile strength (as determined by a Cohesiometer) is greatly increased, giving the stabilized layer greater beam strength. The lime stabilized layer will also form a better barrier to moisture. This stabilized layer will create a firm "working platform" that will remain more stable than the existing soils. This can reduce lost days due to rainy weather.

Three classes of lime treatment are generally specified:

- Sub-base stabilization: This process involves the initial step used in new construction of mixing lime with the soil at a ratio determined by engineering analysis.
- Base stabilization on either new construction or rehabilitation: This application involves the use of lime at a ratio determined by engineering analysis or laboratory testing. On-site mixing is the preferred method of application. Another common method specifies the use of slaked lime. The slaked lime is mixed off-site and applied by tanker trucks fitted with adjustable

Benefits of the Stabilization Process Can Include

- Higher resistance "R" values
- Reduction in plasticity
- Lower permeability
- Reduction of pavement thickness
- Elimination of excavation, material hauling and handling, and base importation.
- Aids compaction
- Provides "all-weather" access onto and within project sites.

Equipment for the Soil Stabilization and Soil Modification Processes Includes:

- Additive spreaders
- Soil mixers (reclaimers)
- Portable storage containers
- Water trucks
- Deep lift compactors
- Motor graders
- Rollers (as specifications require)






nozzles for spreading at specified ratios. The reclaimer follows the tanker, pulverizing the soil and mixing with it the lime additive per design.
- Lime Modification: Extremely wet soils can delay projects and access to sites. This stabilization process involves the use of higher percentages of lime additive to facilitate the "drying out" of these soils. In the past, lime has been used to dry out the top few inches of soil. However, on some sites, conditions may warrant the use of deeper lime modification. The process is accomplished using Stabilization with lime to a depth of up to sixteen inches.

Fly Ash

When lime is the stabilization additive of choice in non-plastic soils (soils with a low Plasticity Index), a second additive is needed to produce the necessary reaction to the lime. The additional additive, known as a pozzolan, is a byproduct generated in the use of coal-fired boilers. Fly ash is the most commonly specified pozzolan, although there are many other types to choose from. The use of fly ash in this process is rapidly growing. Some of the reasons for choosing fly ash are as follows:

- Since fly ash is a byproduct generated during combustion in boilers, it must be disposed of in an environmentally acceptable manner. It can be relegated to a landfill, in which case it would contribute to the ever present problem of expanding and reaching capacity in these facilities. The alternative to this is to use fly ash in a productive and useful manner.
- Fly ash is a minute spherical product, composed of glass with some carbon and crystalline content. Varying amounts of lime are also present. "Type C" fly ash is referred to as "Portland cement without lime" due to the similarities in chemical composition. The use of this material as an additive has shown that it will interact with lime to enhance the strength of the stabilized soil, forming a material with cement-like characteristics. "Type F" fly ash is not a self-cementing additive, but does work well with lime when used in combination. Thorough testing of any additive will determine what material will work best with each specific soil.
- Fly ash, combined with lime and aggregate, will form an excellent road base. In this application, fly ash content can range from 12 to 14% and lime from 3 to 7% as a percentage of the material processed. Portland cement may also be used in lieu of lime to increase early age strengths.

Whatever the specific application, testing and a proper design is imperative to achieve optimum results. The engineer must determine the total quantity of lime and fly ash required to produce the maximum dry density when combined with the project aggregate or soil. The proper ratio between lime and fly ash is critical to the success of the application.

Bituminous Binders

Asphaltic binders are also used in Stabilization, particularly when rehabilitating or reclaiming deteriorated asphalt surfaces. Traditionally, thin lift pavements with two to four inches of bituminous material have been ideal candidates. These include roads or other paved surfaces constructed of chip seals, penetrated bases, and some hot mix asphalt surfaces with little or no aggregate sub-base. Asphaltic binders may also be used in coarse grained soils and mix grained soils.

Asphalt binders include:

- Asphalt emulsions (both anionic or cationic)
- Foamed or expanded asphalt

As a general rule, the asphaltic binder content is around 2 to 4% of the dry weight of the material. The mix design for this process can vary depending on whether an asphalt emulsion or foamed asphalt is used as the stabilizing agent.

Regardless of which bituminous stabilizing agent is used, the mix design process will follow the same general outline:

- Determine the suitability of the soil to be stabilized
- Establish the Optimum Moisture Content (OMC) and Optimum Fluid Content (OFC)
- Determine the Optimum Bitumen Content (OBC)
- Confirm the mechanical properties of the stabilized mix

Gradation requirements are more restrictive if foamed asphalt is used as the stabilizing agent. Materials deficient in fines will not mix well with foamed asphalts. When sufficient fines are not present, foamed asphalt will not disperse properly and will form bitumen-rich agglomerations with the fines that are present.

Soil Cement Applications

Soil Cement is used primarily as a base course for:

- Roads
- Streets
- Airports
- Shoulders
- Parking areas

It is also used for:

- Sub-base for rigid pavements
- Sub-base for flexible and Soil Cement pavements
- Road widening
- Storage or staging areas
- Hazardous waste sites
- Slope protection for earth dams and embankments
- Foundation stabilization
- Reservoir and lagoon linings
- Channel and ditch linings
- Sub-grade stabilization

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