STABILISATION OF PAVEMENT SUBGRADE SOIL USING LIME AND CEMENT: REVIEW

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Abstract-*This paper consists of literature survey on stabilisation of pavement subgrade soil using lime and cement. India is a place of geographical diversity having different soil in different areas. So to improve those areas having poor bearing capacity stabilisation technique is used. Both mechanical and chemical stabilisation methods are used for the improvement of soil strength. In mechanical method, some machines are used for digging the soil and some other type of soil mixed with poor soil in required quantity. After properly mixing of the soil, spread it by machine and compacted with machine up to required strength. In chemical methods soil mixed with chemical compounds like lime, cement, fly ash and terazyme. Though cement is capable of stabilising a wide range of soil types, it is most effective in sandy soil, sand with silt soil, and clay soil having plasticity range low to medium. Lime is primarily use for clay soil having high plasticity.*

Key Words: *Lime; Cement; Soil; Stabilisation; Subgrade; Pavement.*

1. INTRODUCTION

Soil available in nature is very useful for both agriculture and engineering purpose. For engineering point of view, soil plays different roles in the construction of building, highway, railway, airport, harbour, etc. as foundation material. According to the type of soil, strength differs, in case soil having the low strength for the particular structure at the site it is required to improve the strength of soil by using stabilisation technique. Before doing soil stabilisation identify the goals of soil stabilisation, select the appropriate type and amount of stabilisers. Evaluate the material properties and field performance to ensure the designed goals of soil stabilisation to be achieved. Goals of soil stabilisation consist of dry up the construction site and provide a working platform, reduce plasticity index (PI) of soil, improve soil density, reduce shrink or swell characteristics of the soil, improve strength and stability of soil, reduce moisture susceptibility and utilise local materials. Many clayey soils have a potential to shrink and swell with the variation in moisture content. The resulting volume changes in the soil can be unfavorable to any structures built on such soil [7]. A number of stabilization methods have been used to control this shrink/swell behavior and thus prevent the potential damage.

Soil stabilization is an economical and environmental friendly process for altering both chemical and mechanical behaviour of soil via pozzolanic reaction [5]. For many years, researchers in this domain have concentrated their efforts on soil stabilization through the utilization of a range of additives including cement, lime, industrial waste products, fly ash, silica fume and calcium chloride [15, 3]. Chemical stabilization of the soil using lime, cement, fly ash, and their combinations is very common nowadays. Among them lime is the most widely used admixture as they form cementing products which bonds the clay particles thereby reducing the plasticity, shrinkage, swelling and improve the strength characteristics [2,6].

Main objective of this research study was to compare lime and cement as subgrade soil stabilising agents in pavement construction. The study includes a preliminary investigation, construction, monitoring, and post-construction testing.

2. CEMENT AS A SOIL STABILISING AGENT

2.1 Mechanics of soil-cement reactions

There are four mechanisms by which soil is stabilised using cement. The two most important mechanisms are hydration and cation exchange, with carbonation and pozzolanic reactions playing a less significant role.

Hydration: Cement is a complex mixture comprised of many compounds. The prominent compounds that play a major role are C_3S, C_2S, C_3A, and C_4AF [8]. Calcium hydroxide increases the pH water and creates a favourable environment for stabilisation [14, 4].

Cation Exchange: Cation exchange is the second most important mechanism in the stabilisation of a cohesive soil. In this mechanism, a cation from the cement fills a vacant position or exchanges positions with another cation in the clay mineral crystalline structure. This exchange usually results in a reduction in the net surface charge of the clay particle and a consequent lesser attraction for free water molecules.

Carbonation: Lime generated during the hydration of the cement. This lime will react with carbon dioxide present in the surrounding air and form cementitious materials of calcium carbonate. These materials contribute to the improvement of strength of cement stabilised soils [4].

Pozzolanic Reactions: A portion of the lime generated during the hydration process reacts with silica or alumina ions from the clay structure. Mild cementitious material results strengthening the bonds within the stabilised soil [4].

2.2 Types of soils suitable for cement stabilization

Though cement is capable of stabilising a wide range of soil types, it is most effective in sandy soil, sand with silt soil, and clay soil having plasticity range low to medium [1]. Cement may use in highly plastic clays, but generally, it is considered to be more effective when lime is added initially to lower the plasticity index [7]. In general, cement requirements increase as the silt and clay content increase [1]. A rule of thumb is "use lime for clays and cement for sands".

2.3 Engineering properties of cement stabilized soils

The addition of cement to a soil usually results in a modification of the engineering properties of that soil. Not all soils will be modified in the same way or to the same degree.

Plasticity Index: The plasticity index of soil is an indication of its potential to change in volume due to changes in water content. Those soil having a plasticity index of 35 or greater would be expected to have a very high degree of expansion, while a plasticity index of less than 18 would be considered to have a low degree of volume change [12]. Normally, soils with a plasticity index of less than 18 would pose few problems [12]. Usually, cement has a great effect on reducing the plasticity index even at low cement percentages. As the plasticity index increases above 30 [1] or the liquid limit increases above 50 [7], mixing may become difficult. It is common to add 2 to 3 percent of either lime or cement as a pretreatment [7].

Compaction: Addition of cement to a soil usually causes a change in optimum moisture content (OMC) and maximum dry density (MDD). The higher specific gravity of cement produces a higher density [1]. Flocculation generally results in a slight decrease in density along with a slight increase in optimum moisture content [1]. As suggested by [9] moisture content be increased above optimum by 2 – 4 % if there is a delay in compaction.

3. LIME AS A SOIL STABILISING AGENT

Many methods and chemical agents have been used in the past to successfully treat soils to increase their workability. Out of these, lime has been the most effective in stabilizing subgrade. Lime is primarily for use on high clay content soils i.e. for the soil having physical properties such as plasticity index (PI) greater than 15-18, volumetric change greater than 20-30 % and clay content greater than 25-30%.

3.1 Types of soils suitable for lime stabilization

The addition of lime to a medium grained and fine-grain soils reduces the plasticity index and swell while increasing the workability and strength [1]. Montmorillonite react with lime more quickly than kaolinite [7]. According to [10] soil with plasticity indices (PI) between 10 and 30, with 25 percent passing the U.S. No. 200 sieve, are highly reactive with lime. According to [13] soils with as little as 7 percent passing the No. 200 sieve and a PI of 8 can be stabilized with lime. Soils that have plasticity indices higher than 30 should be modified with lime until the PI is at least 30 and then stabilized with cement. The pH of a soil plays an important role in stabilization. Soils having in-situ pH of 7 or greater are more reactive to lime than soils with pH less than 7 [13].

3.2 Mechanics of lime soil reactions

The lime soil reaction is not fully understood. The shrink and swell potential of clays is clearly defined by the diffused layer. The reaction between lime, water, and clay occurs with the cation exchange, where the calcium cations replace the free cations available in water. Adding lime to soil creates a more stable, diffused water layer, which is dramatically reduced in size because of the cation exchange. Once the water layer size decreases, clay particles attract one another more closely through flocculation.

3.3 Engineering properties

For fine-grained soils, lime is an effective stabilizing agent, which has been used successfully to reduce plasticity, increase workability, and decrease the shrink-swell potential. Strength gain is important when the subgrade is to support the overlaying base course. The amount of strength a soil show, depends on the pozzolanic reaction. Plasticity of soils is dramatically decreased with increase in lime; in fact, the soils may become nonplastic. The addition of lime results in a decrease in the MDD and an increase in the OMC. Swell potential of fine-grained soils can also be controlled with the use of lime. The unconfined compressive strength is the best way to select the optimum lime content and is also a good measure of shear strength [10]. In a study conducted by [11], they found that the permeability of the soil increased by as much as 7 to 300 times with lime addition.

3.4 Quantity of Lime needed

Quantity of lime needed is 4 to 6 percent, and it depends on types of soil. The worse the soils, the higher percentage of lime should use. Stabilisation should be a minimum of 15 cm deep for marginal soils; 20-23 cm for poor soils and 25-30 cm for the very worst soils.

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