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A Review on Application of Chemical Additives in Soil Stabilization

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Abstract – *The use of chemical additives in various road construction projects is in vogue in India. Soil stabilization is a method employed for improving the properties of a soil to enhance its index properties and engineering performance. With increasing scarcity of river sand, soil and natural aggregates across the country, there is a need to admix soil with alternate materials which are stable and economical. Mixing these artificially generated additives with existing soil type without completely removing and refilling with another can be an alternative stabilization technique compared to conventional cement mixing which is also highly expensive. In this paper, a review of the previous research studies carried out by various researchers on effective usage of chemical additives is presented.*

Key Words: Soil Stabilization, Chemical Additives, Index Properties, Engineering Performance, Road Construction

1.INTRODUCTION

Soil is a naturally occurring material used for the construction of all except the surface layers of pavements which generally involves concrete and asphalt [1].The response of expansive soils in the form of swelling and shrinkage due to changes in water content is frequently expressed superficially as heaving and settlement of lightly loaded geotechnical structures such as pavements, railways, roadways, channel and reservoir linings [2]. The Mesopotamians and Romans discovered that it was possible to improved soil bases to carry traffic loads by mixing the weak soils with a stabilizing agent like pulverizing limestone or calcium. This was the first chemical stabilization of weak soils to improve their load carrying ability. In fact, a few sections of roadways built by the Romans are still in remarkably good condition 2000 years following their construction [3]. The selection of type and determination of the percentage of additive to be used is dependent upon the classification and the degree of improvement of the soil desired. There is a rapid increase in urbanization and industrialization in developing countries like India and this activity extremely demands to uplift nation's economy and increase the living standards of people. Industrialization, on the other hand, has also caused serious problems relating to environmental pollution due to the disposal wastes in good cultivable land [4].

1.1 Soil Stabilization

Soil stabilization is the process of treating a soil in such a manner as to maintain, alter or improve the performance of the soil as a construction material. The need for economic construction of cement in soil stabilization arises from consideration in the cost of cement [5]. Soil stabilization is widely used in connection with road, pavement and foundation construction. Stabilized soils can also be used for airfields, traffic pavements and parking and storage areas where an all- weather surface is required. Throughout history, there have been a number of improvements in the equipment and technology employed for the material stabilization application. Methods of stabilization may be grouped under two main types a) Modification or improvement of a soil property of the existing soil without any admixture. b) Modification of the properties with the help of chemical additives [6].

1.2 Purpose of Soil Stabilization

Pavement design is based on the premise that specific levels of quality will be achieved for each soil layer in the pavement system. The main purpose of soil stabilization is to improve the strength of sub- bases, bases and in the case of low- cost roads, surface courses. It also plays an important role in improving the permeability characteristics of the subsoil and improve certain undesirable properties, such as excessive swelling or shrinkage, high plasticity and to increase the load- bearing capacity [7]. When it is desired to improve the strength and durability significantly, larger quantities of additive are used. After the additive has been mixed with the soil, spreading and compaction are achieved by conventional means.

2. CHEMICAL ADDITIVES

Chemical additives are manufactured commercial products that, when added to the soil in the proper quantities, improve some engineering characteristics of the soil such as strength, texture, workability and plasticity [8].Additive stabilization is achieved by the addition of proper percentages of cement, lime, fly ash, bitumen, or combinations of these materials to the soil. When more than a single additive is selected, the first additive to be applied may be added in the dry state or as slurry. When added in the bulk state, it is not uncommon for the agent to be spread onto the surface of the material and

then either bladed, disked, scarified or otherwise distributed prior to final stabilization. As slurry, it may be applied by a truck distributor, or mixed directly into the soil through an additive system incorporated into the stabilizer's mixing chamber [9].

Fig-1: Lime Stabilization

The most efficient chemical stabilizers are found to be fly ash, copper slag, sodium silicate, lignin, molasses and lime. Sodium silicate reacts in aqueous solution with soluble calcium salts, forming insoluble and gelatinous calcium silicate which acts as a good pozzolan [10].The natural binding material that holds together the fibres in wood is lignin. It is a major by-product in paper manufacturing industry. Calcium lignosulphate is the constituent which is used as a road binder. Another material that improves the efficiency of soil stabilization is molasses, which is a waste product from the process of manufacturing of sugarcane. A thick, syrupy liquid, it is hygroscopic and can be used as a dust- palliative and binder. Fly ash and copper slag are industrial waste materials obtained from the combustion of coals and smelting of copper respectively.

3. REVIEW OF RESULTS

Soil- lime mixtures are used as sub- base or base courses. Because of the favorable climatic conditions in India and the occurrence of clayey soils in large areas, this technique offers considerable scope. Experiments conducted by Indian Roads Congress (1973) show that the strength of a soil lime-mixture is generally influenced by the lime content. A concentration of lime less than 2 percent is generally not amenable to proper mixing [11]. The benefits of addition of lime depend to a large extent on factors such as purity of lime, the fineness of lime, the degree of pulverization and the curing conditions. Sherwood P. T et.al, studied the effect of lime and cement on expansive clay and found that a number of reactions occur leading to the improvement of soil properties, when lime is added to clayey soils in the presence of water. The cation exchange takes place in the surfaces of clay particles and calcium cation of lime [12]. Basma A. A et.al, found that the effect of cation exchange and attraction causes clay particles to become close to each other, forming floc and the corresponding process is flocculation. It is primarily responsible for the modification of engineering properties of clay soils when treated with lime [13].

Fly ash treatment can effectively reduce the swell potential of highly plastic clays and prevent the swell beneath the smaller foundation pressures [14]. The study conducted by CRRI, New Delhi showed that fine sand with copper slag up to 40 % can be used as fine aggregate in pavement quality concrete as well as in dry lean concrete [15]. Copper slag, when mixed with locally available soil in a proportion of 30% CS and 70 % of the soil, the plasticity index of the soil was reduced by 40% [16]. Mroueh et.al, carried out a life cycle analysis for the use of industrial waste slag in the construction of road which yielded effective conclusions for the reuse of waste by-products [17]. Molasses can be adopted in road construction but it is easily leached out by rain water which can be made to last long by means of an impermeable bituminous surfacing. Lignin closes the voids and thus reduces the penetration of water through the pavement layer. It also retards the rate of evaporation of water and arrests loss of moisture. Expansive materials that exhibit swelling problems include bentonitic mudstones, marls, argillaceous lime-stones and altered conglomerates [18]. Generally, small amounts of additives are required when it is simply desired to modify soil properties such as gradation, workability and plasticity.

4. CONCLUSIONS

1. Utilizing and reusing the industrial additives like copper slag, silica fume and fly ash, the wastage of fertile agricultural land can be avoided.
2. Engineering behavior of expansive soils can be improved by using the chemical additives in embankment construction, land reclamation and for improving sub grade soil conditions.
3. Chemical additives, when added to stabilize weak subsoil conditions tend to be free draining and are not frost susceptible.

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