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Utilization of Solid Wastes for the Stabilization of Expansive Soil: A Review

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Abstract*: Soil which has high shrinkage and swelling property and having poor shear strength has poor stabilization property. Expansive clay soil is characterized by excessive compressive strength, collapse, high swell potential, low bearing capacity, and low shear strength. Such soils are unsuitable for subgrade. These soils are having cracking problems in the dry season and swelling problems in the wet season. By using different techniques, these properties of soil can be improved. The stabilization of soil is one of the important factor used before starting any construction work. In this research paper stabilization of expansive soil is done by using different waste material. The construction of large structures on soils of lesser density becomes a difficult task. The inclusion of some of the industrial waste is one of the soil stabilizing techniques that could be applied successfully to overcome this challenge.

Keywords: Soil stabilization, Expansive soil, Industrial waste, Strength

I. INTRODUCTION

A developing country like India which has a large geographical area and population, demands vast infrastructure i.e. network of roads and buildings. Everywhere land is being utilized for various structures from ordinary house to skyscrapers, bridges to airports and from rural roads to expressways. Almost all the civil engineering structures are located on various soil strata. Soil is often outlined as a material consisting of rock particles, sand, silt, and clay. It is formed by the gradual disintegration or decomposition of rocks due to natural processes that include disintegration of rock due to stresses arising from expansion or contraction with temperature changes. Weathering and decomposition from chemical changes that occur when water, oxygen and carbon dioxide gradually combine with minerals within the rock formation, thus it is breaking down to the sand, silt, and clay. Transportation of soil materials by wind, water, and ice forms different soil formations such as those found in river deltas, sand dunes and glacial deposits. Temperature, rainfall, and drainage play important roles in the formation of soils as in the different climatic regions. Under totally different drain regimes, different soils will be formed from the same original rock formation. Construction of any structure on expansive soil is difficult due to its swelling and shrinkage property. Due to a large amount of water the soil starts swelling and to less water the soil shrinks so it is highly unstable for doing any construction work. The soil can be stabilized by using soil stabilization techniques. Soil stabilization is that the method that involves enhancing the physical properties of the soil so as to enhance its strength, durability, etc. by blending or mixing it with additives. The different types of methods used for soil stabilization are Soil stabilization using cement, Soil stabilization using lime, Soil stabilization using bitumen, Chemical stabilization, soil stabilization using waste material, etc., The stabilization of expansive soils by using admixtures such as cement or lime is found lack of interest because of the increasing cost of cement and environmental concerns related to production of these admixtures. Thus, it is a time requirement to search for materials that can be work as an effective, economical and eco-friendly soil stabilizing material to improve the soil properties. In such a scenario, one of the most effective and economical methods for soil stabilization is the utilization of waste materials for altering the soil properties. The rapid industrialization throughout the country results in the production of a huge quantity of waste materials. These waste materials can be classified based on source of their generation as follows: industrial wastes such as fly ash, ground granulated blast furnace slag, waste paper sludge, copper slag, bottom ash etc., agricultural wastes such as rice husk ash, bagasse ash, groundnut shell ash etc., domestic wastes such as incinerator ash, waste tire etc. and mineral wastes such as quarry dust, marble dust etc. This type of soil stabilization will give the best solution to dispose of the wastes and will also help to sustain the environment. Because of this waste material cause pollution to the environment and harmful effects on human life. Advantages of soil stabilizations are: If during the construction phase weak soil strata are encountered, the usual practice followed is replacing the weak soil with some other good quality soil. With the application of soil stabilization technique, the properties of the locally available soil (soil available at the site) can be enhanced and can be used effectively as the subgrade material without replacing it. The cost of preparing the subgrade by replacing the weak soil with a good quality soil is higher than that of preparing the subgrade by stabilizing the locally available soil using different stabilization techniques. The strength producing parameters of the soil can be effectively increased to a required amount by stabilization and hence increased the bearing capacity of the soil. Gives more stable structures in the slope.

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II. LITERATURE REVIEW

The requirements to enhance the soil properties for construction works leads to the utilization of a range of stabilizers. One of them is the stabilization with the help of dust/powder for example waste materials with and without a binder like cement [1, 2], Quarry dust [3], marble dust [4], tiles powder [5], and baryte powder [6] are some of the dust/powder from waste have been nowadays successfully utilized for the stabilization of expansive soil. However, some of these stabilizers are either pricey or rare. Such as cement stabilization was adjudged the most impregnable due to its sufficiency. Howsoever, the increasing price of cement has delimited its use. It is consequently become essential to make use of common materials having excellent properties [7]. There is a large variety of materials available for the construction industries. The desire and sustainability of a specific material rely largely on its availability, nature of the project, independent preference, durability, propinquity and financial consideration [8]. There has been a radical variation in the volume and properties of the solid waste owing to the increase in population, urbanization, industrialization, and change in lifestyle. As a result, solid wastes become more harmful to surroundings and needs cautious disposal practices. It has been evaluated that about 30% of daily manufacturing in the ceramic industry goes as waste [9]. Many studies have been carried out in regard to reinforcing the soil, so as to enhance its properties. Some of the notable works are mentioned here.

A. Ground Granulated Blast Furnace Slag

For the stabilization of soil ground granulated blast furnace slag (GGBS) is used and it was found that with the addition of GGBS in the soil, its engineering properties like liquid limit, plastic limit, plasticity index, dry density, unconfined compressive strength, and CBR increased. The addition of GGBS in the clay, lime, and gypsum system results in a reduction in the expansion and has a small variation in compressive strength [10]. Ground Granulated Blast Furnace Slag (GGBFS) and Fly Ash (FA) was used as a soil stabilizing material to improve the engineering properties of soil [11]. From the test results, it was found that with fix percentage of GGBS (10%) and varying percentage of FA up to 10% the OMC decreases but further increases of FA content results in an increase of OMC. The CBR value for the soaked and un-soaked condition was increased with fix percentage of GGBS (10%) and varying percentage of FA up to 10% by weight of soil then decreases with increase in the percentage of Fly ash. It was concluded that 10% GGBS and 10% Fly ash by weight of soil gave better results as a soil stabilizer.

B. Rice Husk

Rice husk is the waste product which comes from paddy crop. After burning it gives the rich amount of silica which may be used as a stabilizer for soil stabilization. Rice husk waste is produced in large quantity in rice husk mills and is disposed-off in open land. Therefore use of rice husk in the foundation of buildings and in road constructions to improve the bearing capacity of the soil and to reduce the area of open land needed for its disposal. Rice Husk is used as a chemical stabilizer due to the presence of a high amount of silica after burning the husk. It has been shown that use of RHA as a stabilizer is not only an affordable green technology but also gives expansive clays the strength required for the Subgrade pavement layer. Utilization of these wastes could solve the disposal problem and reduce the cost of waste treatment [12]. When rice husk incinerated, ash is obtained and it is called as rice husk ash, and it contains a high amount of silica. The presence of the high amount of silica makes it a valuable material for use in industrial application [13].

C. Marble Dust Powder

Marble dust is the wastes/dust produced during the cutting and polishing of marble. Marble dust powder is effective waste material in the stabilization of expansive soil, which improve the index and engineering properties of the soil [14]. The influence of marble dust, fly-ash and Beas sand on sub-grade characteristics of expansive soil is investigated and it was found that they increase the effectiveness as well as stability of soil [15].

D. Jute Fiber

Subgrade governs the performance, life span, and effectiveness of the pavement. The entire load coming over the pavement is ultimately borne by the subgrade. Thus, the subgrade plays a very important role in the pavement design. In order to enhance the engineering properties, soil can be reinforced using jute fiber. Jute fiber is preferable because of its better durability, high tensile strength and capacity to withstand rotting and heat, porous texture which gives it good drainage and filtration properties. Moreover, jute is locally available, cheap, eco-friendly and biodegradable. Fiber-reinforced soils show greater extensibility, small loss of post-peak strength, isotropy in strength and absence of planes of weakness [16]. The effectiveness of jute fibers in controlling the swelling behavior of black cotton soil measured in the lab with and without the use of randomly reinforced jute fibers in the soil [17].

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From the test result, it was concluded that there was a substantial increase in shrinkage limit, optimum moisture, dry density, CBR value and shear strength of the soil and also the addition of jute fibers to black cotton soil decreased the swelling behavior. The experimental study for the application of jute fiber in subgrade soil was conducted and it was found that the increase in the CBR value of subgrade soil with the increase in jute content as well as the increase in length and diameter of jute threads [18].

E. Coconut Coir

Coconut coir has the highest strength among all-natural fibers and high water absorption. Due to the high lignin content rate of decomposition of coconut coir is less than compared to all other natural fibers. It retains 20% of its strength even after 1 year [19]. These qualities are responsible for use of coconut coir in soil stabilization. These can be used to reinforce soil that is poor in tension reducing the applied stress and hence preventing the rutting of subgrade [20]. From the vast literature review conducted it was observed that cement acts as good stabilizer and coir alone cannot provide satisfactory results, therefore a combination of cement and coconut coir is investigated [1]. For both the light and heavy compaction tests in lateritic soil treated with cement and coir fiber, MDD was higher in each the cases compared to it of untreated soil whereas OMC was not up to that of untreated soil once it had been mixed with fiber element and 6 percentage of cement. It was found that CBR values for both the % of fibers enhanced significantly because the amount of curing period increased, also the finding values are too much compared to that of untreated soil [1]. Experiment on stabilization of soil with coir geotextile was performed and it had been found that reinforcing the soil with geotextile will improve the strength characteristics of the soil and hence there is an improvement of CBR by 140% and there is a reduction in the rut depth by 17% [21].

III. SUMMARY AND CONCLUSIONS

Based on the review of the mention of the different work in literature, the various conclusions can found out are as follows:

The stability of the pavement depends upon the strength of the subgrade. In literature, there are some studies that concentrated on exploring the optimum dose of binders to be mixed with certain types of soils to gain a sizable increase within the unconfined strength and to get the desired improvement. Utilization of waste marble powder can diminish the disposal problem and preserve the ecological system.

From this review paper, it may also be concluded that the effectiveness of the materials explained above as good as a stabilizer for the expansive soil to enhance its strength. It was also concluded that the preferred properties may be gained by stabilizing it with different materials and the appropriate construction may be done with the higher economy by the help of waste materials like GGBS, rice husk, marble powder, jute fiber, coconut coir fiber, etc. But, an additional investigation has to be done so, their effectiveness in field application instead of focusing in term of experimental studies. Other investigation may also be done so that different materials that might be effective as soil stabilizer can be found.

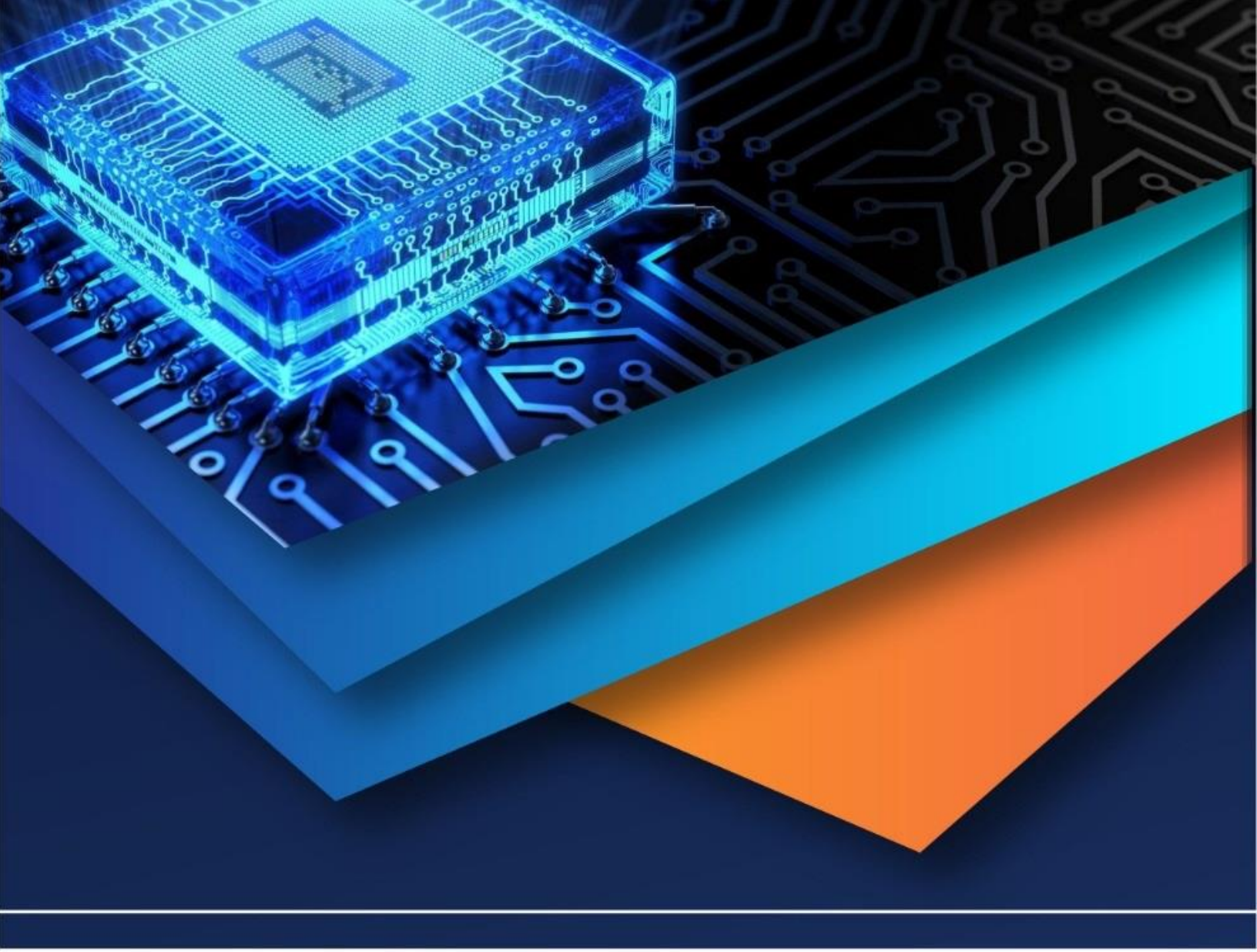
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