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Review of Industrial Waste Used In Stabilization of Expansive Soil in Road Subgrade

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Abstract: The Aim of this review paper is to study the various industrial waste used for stabilization of Expansive soil in road subgrade. Expansive soil have tremendous strength but it becomes very soft when it getting wet, It expands/swells due to its mineralogical composition during its wet condition, It creates cracks or consolidated when it is dry. Expansive soils can be found on almost all the continents on the Earth. First various literature was studied and finally an industrial waste Iron Sludge was suggested because of its higher density for stabilization of expansive soil.

Keywords: Expansive Soil, Stabilization of Expansive Soil and its Methods, Iron Sludge.

I. INTRODUCTION

Road surface or pavement is the durable surface material laid down on an area proposed to sustain vehicular or foot traffic, such as a road or walkway. In the past, gravel road surfaces, cobblestone and granite setts were used, but these surfaces have been replaced by asphalt or concrete pavement on a compacted base course. Material layers are usually arranged within a pavement structure in the order of decreasing load bearing capacity with the highest load bearing capacity material on the top and the lowest load-bearing capacity material on the bottom. A typical flexible pavement structure consists of:

1. Surface Course
2. Base Course
3. Subbase Course

A. Expansive Soil

Expansive soil is one of major soil deposits of India. Expansive soil exhibit high rate of swelling and shrinkage when exposed to changes in moisture content and hence have been found to be most troublesome from engineering consideration. The cracks in expansive soils are usually more than 50mm wide and several millimeters deep. The Expansive soils have low strength and are susceptible to excessive volume changes, making their use for construction purposes very difficult. Instability of these soils causes more damage to structures than any other natural hazard, including earthquakes and floods, unless proper soil stabilization performed. Expansive nature of this soil negatively affects its bearing capacity. Replacement of expansive soil with a non-expansive material is a common method of reducing shrink-swell risk. In the case when expansive soil or stratum is thin, then the entire layer can be removed. However, often the soil or stratum extends too deep and in that case, this method is not economically efficient.

B. Problem Faced in Expansive Soil

- Swelling of soil in the subgrade.
- Shrinkage creates crakes in subgrade in a dry session.
- Consolidation creates uneven pavement in dry session.
- Low CBR value causes the high thickness of layers.
- Low Permeability and low shear strength.

II. STABILIZATION OF EXPANSIVE SOIL

Soil Stabilization 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 sub-grade to support pavements and foundations. The prime objective of Soil Stabilization is to improve the California Bearing Ratio of in-situ soils.

A. Methods of Soil Stabilization

- Soil Replacement
- Sand Cushion Method
- Cohesive Non-Swelling Layer
- Mechanical Stabilization
- Stabilization Using Reinforcement
- Chemical Stabilization
    - Stabilization with Lime
    - Stabilization with Cement
    - Stabilization with Fly Ash etc.

II. LITERATURE REVIEW

Various literature was referred and the summary was listed below:
Karthik .S et al. [1] used waste material Fly ash derived from combustion of sub-bituminous coal at electric power plants in the stabilization of soft fine-grained red soils. The stabilized red soil with 6 % of Fly Ash achieves bearing capacity of 35 Kg/mm^2 from 10 Kg/mm^2. The CBR value of borrowed red soil is 3.1. From design curve in A type traffic, pavement thickness for soil is 12 inches. CBR value of stabilized soil is 4.82. Pavement thickness to this CBR value is 8.5 inches.

S Bhuvaneshwari et al. [2] Used Fly Ash to stabilize the expansive soil. Workability and dry density are maximum at 25 % Fly Ash mixture to soil. As the percentage of Fly Ash Increases with 15, 20 and 25 % the maximum dry density is obtained for moisture content between 12 to 14%. Disk Harrow was suggested to use for mixing Fly Ash and soil on site.

P VenkaraMuthyalu et al. [3] Treating with electrolytes i.e., potassium chloride, calcium chloride and ferric chloride were used for stabilization of expansive soil. Liquid limit values are decreased by 57%, 63%, and 70% respectively for 1% of KCl, $CaCl_2$ and $FeCl_3$ chemicals added. Shrinkage limit of stabilized soil is increased from 12% to 15.1%, 15.4%, and 16% respectively for KCl, $CaCl_2$, and $FeCl_3$. The FSI values are decreased by 40%, 43% and 47% for 1% of KCl, $CaCl_2$ and $FeCl_3$ treatments respectively. The CBR values are also increased by 80%, 103%, and 116% respectively for 1% of KCl, $CaCl_2$ and $FeCl_3$ treatment. The UCS values are increased by 133%, 171% and 230% respectively for 1% of KCl, $CaCl_2$ and $FeCl_3$ respectively.

A V Narasimha Rao et al. [4] used Soil reinforcement with fabrics. The CBR value increases with increase in a number of reinforcing layers. The rate of increase in CBR value is high from one layer to two layers in case of natural fabrics such as coir and jute, whereas the rate of increase in CBR value is high from three to four layers in case of synthetic fabric i.e., geogrid. The maximum CBR at four layers of soil with coir, jute, and geogrid are of the order of 127%, 99%, and 74% respectively. Geofabrics are more suitable for low load-bearing soft soils.

Dr. Robert M. Brooks [5] shown that Stress-strain behaviour of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the fly Ash content was increased from 0 to 25%. When the RHA content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% and CBR improved by 47%. An RHA content of 12% and a fly Ash content of 25% are recommended for strengthening the expansive subgrade soil while a fly Ash content of 15% is recommended for blending into RHA to form a swell reduction layer.

Aditya Kumar Anupam et al. [6] used Industrial waste materials viz. fly ash (FA), rice husk ash (RHA) & bagasse ash (BA) and agricultural waste material rice straw ash (RSA) in the stabilization of soil. Shrinkage limit was improved in all admixture but highest 30 % improve in RHA. CBR value was improved in all admixtures but highest in 20% RSA content, which increased the CBR from 11.87 to 17.74%. Optimum moisture Content was improved and Dry Density was decreased for all admixtures.

Akshaya Kumar Sabat et al. [7] show that optimum percentage of RHA is found out be 10%.The MDD goes on decreasing and OMC goes on increasing irrespective of the percentage of addition of Marble dust to RHA stabilized expansive soil. The UCS value was increased 228% at 20% addition of marble dust. The soaked CBR were achieved 293% at 20% addition of marble dust. The swelling pressure was decreasing to zero from 112 KN/m2 at 25% Marble dust. For best stabilization effect, the optimum proportion of soil: Rice husk ash: marble dust was found to be 70:10:20.

S A Naeini et al. [8] Used geosynthetics in road and airfield construction. The inclusion of one layer geogrid (at top of layer 3) in unsoaked soil samples with different PI values causes 40% increase in CBR results compared to unreinforced soil samples. While for two layered geogrid inclusion (at top of layers 2 and 4) the CBR values increases 24, 29 and 40% for PI values of 10, 16 and 23% respectively. Thus, placing one layer of geogrid at top of layer 3 (near the surface) has more effective performance in unsoaked condition. However, in soaked conditions the CBR values for two layered geogrid inclusion (at top of layers 2 and 4) increase about 35% at different PI values, which is more than one layered geogrid inclusion (at top of layer 3). Therefore, in soaked condition, placing 2 layers of geogrid (at top of layers 2 and 4) is more effective in the CBR values.

Babagouda Patil et al. [9] studied that the CBR of a soil increases by 50-100% when it is reinforced with a single layer of geogrid. The amount of improvement depends on the type of soil and position of geo-grid. CBR of sub-grade soil is 5.7 % without reinforcement and when geogrid was placed at 0.8 H from the bottom, the CBR value increased to 12.36 % in soaked condition. The stress-strain behaviour of subgrade soils under static load condition improved considerably when geogrid was provided at the optimum position. Physical and strength characteristics of the soil are improved. Stabilization provides sound pavement foundation and reduces the thickness of the overlying layers.

Nadgouda K A et al. [10] used lime as a soil stabilizer. When lime is added then a pozzolanic reaction takes place and it permanently transforms them into a strong cementitious matrix. Black cotton soil showing low to the medium swelling potential from Latur, Maharashtra was used for determining the basic properties of the soil. Changes in various soil properties such as Liquid limit, Plastic Limit, Maximum Dry Density, Optimum Moisture Content, Differential Free Swell, Swelling Pressure and California Bearing Ratio were studied. The plastic nature of the soil decreases, swelling decreases and the stiffness of the soil increases as the lime content increases.

Vikas Rameshrao Kulkarni et al. [11] investigates the effect of introducing waste slag and glass fibers as sustainable additives to strengthen the black cotton soil. Mixing of soil with varying percentage of slag lead to decrease in optimum moisture content, increase in maximum dry density, decrease in swelling Index and increase in CBR value in soaked condition. Mixing of soil with the optimum percentage of slag and varying percentage of 6mm glass fiber and 12 mm glass fiber. Mixing of soil with 12mm fiber with soil had been a better performance as compared to 6mm fiber and it is concluded that CBR value increases with increase in the length of fiber. The optimum value of slag addition is 25 %.

M Rupa Kumar et al. [12] studied the improvement in geotechnical properties of an expansive soil stabilized with waste Iron Powder. The liquid limit and Plasticity Index (P.I.) values are decreasing with the percentage increase of Iron Powder in the soil, while the Plastic limit remained constant. The Maximum dry density increased up to 6% replacement of Iron Powder and decreased further. By the comparison of the tests conducted (Atterberg Tests, Compaction Tests, and CBR Test), it is recommended to replace 6% of Iron Powder in Soil to get maximum dry density, higher CBR Values which are the indicators of Strength of a Soil.

III. SUMMARY OF LITERATURE AND MATERIAL SELECTION

After a study of literature, it seems that some industrial waste materials are viable for stabilization of expansive soil. So we try to check some other industrial waste material like Iron Sludge to stabilize expansive soil. It is generated in Pharmaceutical Industry. It is the by waste product from reduction process its density is 32.33 KN/mm^2. If these industrial waste materials can be suitably utilized in highway construction, the disposal problem can be partly reduced. Generally, these solid wastes have occupied several acres of land around plants throughout the country. Pavement performance studies are to be done for these waste materials for Stabilization of soil with two benefits:

- It will help to clear the valuable land of huge waste dumps.
- It will also help to solve the shrinkage and swelling problem of Expansive soil.

CONCLUSION

As from above discussion and literature review, it is concluded that some industrial waste product can be viable for stabilization of expansive soil. So we try a different industrial waste Iron Sludge for stabilization of soil. Because of its higher density, its strength is also high and its California bearing ratio (CBR) value is also high.so we thought that it may not be used in concrete but it can be used in road construction for stabilization of expansive soil.

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