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UTILIZATION OF FLY ASH ACTIVATED BY CEMENT FOR PAVEMENT SUBGRADE

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Abstract— **The performance of pavement is very responsive to the characteristics of the soil subgrade. For that reason, weak subgrade is enhanced by adopting the most efficient stabilization technique. Stabilization with fly ash activated with cement was found to be an effective option for improvement of soil properties. Expansive soil treated with varying percentages of fly ash, 0%, 5%, 10%, 15% and 20% combined with 0%, 2%, 4%, 6%, 8% cement content. The experimental results show that addition of cement-fly ash admixture to the soil has great influence on its properties.**

The effectiveness of the use of waste fly ash (FA) and cement (OPC) in the stabilization of subgrade soils and the reasons likely to influence the degree of stabilization were investigated. Incorporating waste fly ash (FA) and cement (OPC) as additives leads to significant environmental and economic contributions to soil stabilization. This study involves laboratory tests to obtain the Atterberg limit, free swell index (FSI), the unconfined compressive strength (UCS), the California bearing ratio (CBR).

Expansive soils pose significant challenges in construction due to their tendency to swell and shrink with changes in moisture content, leading to structural damage and instability. Optimum mix proportions are identified based on the desired engineering properties and environmental considerations. Moreover, the use of fly ash and cement as stabilizing agents offers a sustainable solution by utilizing industrial by-products and reducing the demand for natural resources.

Keywords— **fly ash, cement and soil for stabilization**

I. INTRODUCTION

Subgrade soil provides base for the whole pavement structure. Weak subgrades of expansive soil has great tendency to swell and shrink when in contact with water. This behaviour is believed to have been derived from clay rich of montmorillonite mineral. These expansive soils can be improved through the addition of chemical or cementitious additives. These additives range from waste products to manufactured materials which include fly ash, cement, lime and proprietary chemical stabilizers. Weak subgrade soils are usually improved by cement or lime. In fact, cement stabilization provide an effective solution to the problem of fatigue failures caused by repeated high deflection of asphalt surfaces where a weak subgrade exists in the pavement structure.

Experiences in areas of expansive subgrades, show significant improvement in strength and a marked decrease in deflection when subgrades are stabilized with cement, while treatment with lime or fly ash is a well known practice adopted to reduce swelling behaviour. The effect of fly ash stabilization on soil properties varies widely depending on the type of fly ash and its composition. Due to the lack of self-cementitious characteristics, class F fly ash activated by cement result in greatest improvement in strength and swelling of expansive soil. Some previous researchers pointed out that treatment of subgrade soils with cement-fly ash admixture performs better than lime-treated soils particularly in soils with low strength and high swelling properties.

Soil is the basic construction material. It supports the substructure of any structure and it is the subgrade which supports the sub base/base in the pavement. The existing soil at a location may not be suitable for the construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling in case of expansive soils. Fly ash, a byproduct of coal combustion in power plants, has gained attention as a sustainable alternative in construction practices. . Cement, on the other hand, has long been recognized for its ability to bind soil particles, resulting in enhanced load- bearing capacity and reduced susceptibility to moisture-induced damage.

The foundation of any durable pavement lies in the stability of its subgrade soil. Subgrade instability can lead to premature deterioration of roads, causing safety hazards and significant maintenance costs. In regions where soil conditions are less than ideal, such as expansive clay or weak sandy soils, traditional methods may fall short in providing long- lasting solutions. However, advancements in soil stabilization techniques, particularly through the use of fly ash and cement, offer promising avenues for enhancing subgrade stability and extending pavement lifespan.

II. PROPOSED ALGORITHM

A. OBJECTIVES:

- The major objectives of the project are as follows:
- To study the properties of black cotton soil made available.
- To check for the suitability of cement-fly ash combination as a stabilizing agent for black cotton soil.
- To obtain the most efficient proportion of cement, fly ash and soil to be mixed for its stabilization.
- To explore the possibility of using fly ash in road construction.
- To study the effect of fly ash and cement on proctor's density and OMC of clayey soils.
- To study the changes in CBR of soil by addition of fly ash and cement.

III. METHODOLOGY:

- **Stabilization using cement:**

1.Kowalski et al. [7],Portland cement is hydraulic cement made by heating limestone and clay mixture in a kiln and pulverizing the resulting material which can be used either to modify or to improve the quality of the soil or to transform the soil into a cemented mass with increased strength and durability. The amount of cement used will depend upon whether the soil is to be modified or stabilized.

2. Kent Newman and Jeb S.Tingle [5] in their study of previous research efforts. Portland cement was used as the stabilizer control for comparison of properties to the polymers and was used at concentration of 2.75%, 6% and 9%. Previous research work have shown that the addition of inert material (sand) to swelling soil can be a method of stabilization of soil.

3. Bahai Louafi and Ramdane Bahar [1] in their experimental work have study the effect of performance of an addition of sand as stabilizer on swelling soil. Based on the study undertaken, they found that the addition of sand reduces consistency limits. They have also worked on introducing sand layer into two different configurations and found that these layers effectively reduce the swelling of soil.

4. Study by Rao and Shivananda (2005): Found that adding 6% cement to black cotton soil reduced the plasticity index significantly, indicating improved workability and reduced plasticity. The swell potential was reduced by up to 80%, demonstrating a substantial improvement in stability.

5. Al-Rawas et al. (2002): Demonstrated that the unconfined compressive strength (UCS) of black cotton soil increased from 200 kPa to over 600 kPa with the addition of 8% cement. This significant improvement in strength makes the soil more suitable for load-bearing applications.

- **Stabilization using Fly ash:**

1. Zala Yashwantsinh et.al, (2013): The authors had worked on Stabilization of black cotton soil using fly ash in various proportions (5%,10%,15%). These were the observations and conclusions made from the study. Liquid limit was decreasing with increase in percentage of fly ash and Plastic limit was decreasing with increase in percentage of fly ash.

2. Saxena Anil Kumar (2013)- Effect of fly ash and lime on engineering properties of BC soil. A liquid limit & Plastic limit was increases with increases in percentage of fly ash & lime. Compaction characters of soil increase with increasing % of fly ash & lime. CBR value of BC soil increases with increase in % of fly ash & lime.

3. Sivapullaiah(1996) reported that the addition of fly ash decreased the liquid limit of black cotton soils and studied the effect of fly ash on the index properties of these soils from Karnataka in India . **Bhoominadhan and Hari (1999**) proposed the use of fly ash in construction works like brick making and soil stabilization.

IV. RESULTS AND DISCUSSIONS:

Laboratory experiments were carried out on natural soil samples to evaluate various properties. The amount of fly ash for stabilization is taken in the proportions of 5%, 10%, 15% and 20% by dry weight of soil and the amount of cement was taken at 2%,4%, 6% and 8% by dry weight of soil. Using these proportions, mix samples were prepared as given below and a set of laboratory tests were performed to determine the index properties, swelling and CBR values of both natural soil and mixed proportion samples. Mix Proportion Samples of soil, Fly ash and cement used for Stabilization are:

Natural soil.
1. Soil +5% Fly ash +2% Cement.
2. Soil +10% Fly ash +4% Cement.
3. Soil +15% Fly ash +6% Cement.
4. Soil +20% Fly ash +8% Cement

Atterberg limits in sub grade soil by adding fly ash and cement.

MIX PROPOR TION	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTIY INDEX
Natural soil	43.27	29.81	3.46
Soil+5% FA+2% OPC	45.61	33.78	11.83
Soil+10% FA+4% OPC	42.12	29.26	12.86
Soil+15% FA+6%OPC	38.6	27.5	11.1
Soil+20% FA+8% OPC	38.21	26.4	11.81

The Effect Of Adding Cement And Fly Ash On The Ucs Value

MIX PROPORTION	OPTIMUM MOISTURE CONTENT	MAXIMUMDRY DENSITY
Natural soil	18.21	2.13
Soil+5%FA+2%OPC	17.42	2.21
Soil+10%FA+4%OPC	16.98	2.28
Soil+15%FA+6%OPC	16.01	2.42
Soil+20%FA+8%OPC	17.23	2.31

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