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Stabilization of Black Cotton Soil by Using Flyash and Granite Dust

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ABSTRACT:

Soil stabilization with fly ash and granite dust is common practice in the construction industry. In this process, fly ash and granite dust are mixed with soil to improve their strength, durability and stability. Using fly ash and granite dust as a stabilizing agent is environmentally friendly and inexpensive, making it a popular choice for soil stabilization.When mixed with soil, fly ash reacts with the soil to form a stable, solid material. On the other hand, granite dust is a waste material generated from cutting and polishing granite stones. It contains high levels of silica and alumina, making it an ideal soil stabilization material. This project work aims to evaluate the effect of adding 0%, 5%, 10%, 15%, 20% FLY ASH and granite dust to stabilize the extensive soil and verify its suitability as a construction material for roads, embankments and embankments. The process of soil stabilization with fly ash and granite dust involves mixing the two materials with soil in specified proportions, followed by thorough mixing and compaction. The resulting stabilized soil has improved strength, reduced permeability and increased durability. First, the physical properties of the expansive soil samples were evaluated using sieve analysis, Atterberg limit, light compaction test and UCS test. In the second phase of the test program, propellant was mixed with 5%, 10%, 15%, 20% fly ash and granite dust as a percentage of the propellant dry weight. Finally, it improves the overall quality and stability of the soil, resulting in durable and long-lasting structures.

Keywords: FLY ASH, Granite dust, Light compaction test, UCS test

1. INTRODUCTION

Soil stabilization is the process of improving the physical properties of soil to increase its strength, durability, and stability. The stability of soil is crucial for constructing safe and long-lasting structures, such as buildings, roads, bridges, and dams. The stabilization of soil involves adding or mixing various materials with the soil to modify its properties. These materials are known as stabilizing agents and can be natural or synthetic. Stabilizing agents can improve soil properties such as strength, durability, compressibility, and permeability. Soil stabilization is necessary when the natural soil is not suitable for construction purposes due to its poor engineering properties. Poor soil properties can result in problems such as settlement, soil erosion, and poor bearing capacity, leading to structural failures. There are several methods of soil stabilization, including chemical stabilization, mechanical stabilization, and physical stabilization. The choice of method depends on various factors such as soil type, the desired properties, and the intended use of the stabilized soil.

Fly ash is a fine powdery material that is a byproduct of burning coal in coal-fired power plants. It is composed primarily of inorganic minerals and small amounts of carbon. The composition of fly ash varies depending on the type of coal burned, the temperature of the combustion process, and other factors. Fly ash is a commonly used stabilizing agent for soil due to its high content of silica and alumina, which can react with the soil to improve its strength and stability.

Granite dust is a waste material generated during the cutting and polishing of granite stones. It is a fine powder that is composed primarily of silicon dioxide (SiO2), aluminum oxide (Al2O3), and other mineral compounds. Granite dust is a commonly used stabilizing agent for soil due to its high content of silica and alumina, which can react with the soil to improve its strength and stability. The use of granite dust for soil stabilization is also environmentally friendly as it reduces the amount of waste generated by the granite processing industry.

2. MATERIALS

2.1 Black Cotton Soil

Expansive soils, popularly known as black cotton soils in India, are among the most problematic soils from a civil engineering perspective. Soil that tends to expand in volume in the presence of water and decrease in volume in the absence of water is called expansive soil. Expansive soil is an extremely plastic soil usually containing montmorillonite and other active clay minerals. The more clay there is in the soil, the higher the soil swells and the more water the soil can absorb. The soil sample for this study was collected at a depth of 1.5 to 2 meters from the Vongole Dist. The soil was dried and pulverized to conduct the various experimental studies.

Figure: 2.1 Expansive Soil

The photo of the soil collected from the above location has been presented in Figure 1. The index properties and mechanical properties of the soil were evaluated experimentally according to the procedure of the relevant Indian Standard Codes.

2.2 Fly Ash

- Silicon Dioxide (SiO_2): 50-70%
- Aluminum Oxide ($Al2O_3$): 20-35%
- Iron Oxide ($Fe2O_3$): 2-15%
- Calcium Oxide (CaO): 2-10%
- Titanium Dioxide (TiO_2): trace amounts
- Sulfur trioxide (SO_3): trace amounts
- Magnesium Oxide (MgO): trace amounts

Figure: 2.2 Fly Ash

2.3 Granite Dust

- Silicon Dioxide (SiO_2): 60-70%
- Aluminum Oxide (Al_2O_3): 15-25%
- Iron Oxide (Fe_2O_3): 2-5%
- Calcium Oxide (CaO): 2-5%
- Potassium Oxide (K_2O): 2-5%
- Sodium Oxide (Na_2O): 2-5%
- Titanium Dioxide (TiO_2): trace amounts

Figure2.3: Granite Dust

3. LITERATURE REVIEW

1. Muhammad Arslan Hanif and Syed Waqar Hussain published a review paper titled "Soil stabilization using fly ash and granite dust: A review" in the Journal of Building Engineering in 2019. The review summarizes the recent research on the use of fly ash and granite dust in soil stabilization and highlights their effectiveness in improving soil properties.
2. In 2021, Muhammad Asad Khan and Muhammad Uzair Khan published a literature review titled "Soil Stabilization using Fly Ash and Granite Powder: A Review" in the Journal of Advanced Research in Dynamical and Control Systems. The review examines the potential of fly ash and granite powder as soil stabilizers and discusses their effectiveness in improving the strength and stability of soils.
3. "A review on stabilization of expansive soil using fly ash and granite dust" by Sreeja S. and Dr. S. R. Gandhi, published in the International Journal of Civil Engineering and Technology in 2021, provides an overview of recent studies on the use of fly ash and granite dust for stabilizing expansive soil. The review summarizes the benefits and limitations of the combination and highlights the need for further research in this area.

4.TESTS CONDUCTED ON BLACK COTTON SOIL

4.1 Liquid Limit

The liquid limit soil test is a standard laboratory test used to determine the plasticity index of a soil. The plasticity index is a measure of the soil's ability to change shape without breaking, and it is an important factor in determining the soil's engineering properties.

Figure 4.1: Casagrande's Liquid Limit device

TABLE 4.1

S. No	Description of item	Liquid limit
1	BLACK COTTON SOIL	50%
2	85% BCS+5% GRANITE DUST +10% FLYASH	31.5%
3	75% BCS+10% GRANITE DUST+15% FLYASH	30%
4	65% BCS+15% GRANITE DUST + 20% FLYASH	27.27%

5. Plastic Limit

The plastic limit is another important parameter for evaluating the plasticity of soils. It is defined as the water content at which soil begins to behave plastically when rolled into a 3mm diameter thread.

Figure5.1: Plastic Limit

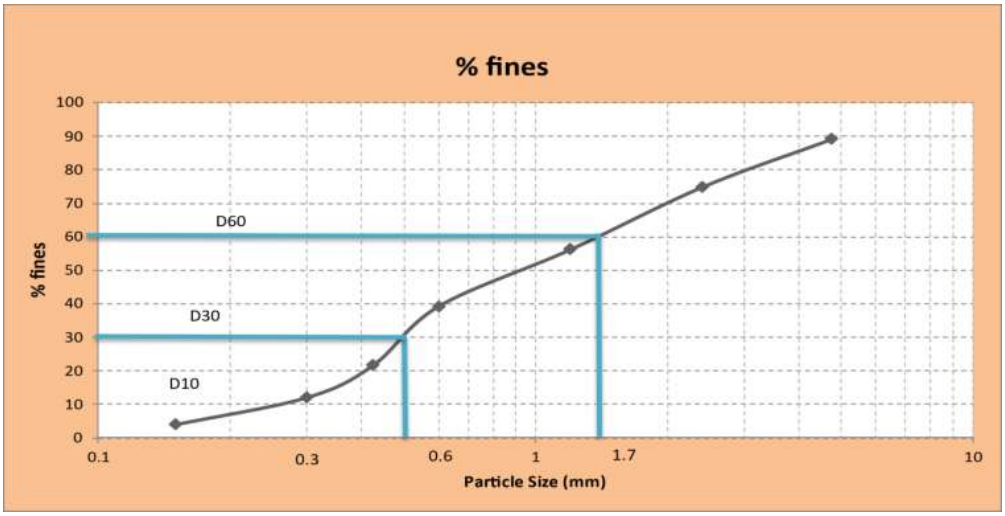
TABLE 5.1

S. No	Description of item	Plastic limit	Plasticity index
01	**100% BCS +0% FLYASH+0% GRANITE DUST**	**25**	**25**
02	85% BCS+5%GRANITE DUST +10%FLYASH	22.22	9.28
03	75% BCS+10%GRANITE DUST +15%FLYASH	20	10
04	65% BCS+15%GRANITE DUST +20%FLYASH	14.28	12.99

6. Dry Sieve Analysis

Dry sieve analysis is a method of particle size analysis commonly used in soil science and geology. The process involves passing a sample of soil or sediment through a series of sieves with progressively smaller mesh sizes, which separates the particles into size fractions. The sieves are typically stacked in order of increasing mesh size, with the largest on top and the smallest on the bottom.

Figure 6.1: Dry Sieve Analysis



Graph 6.1

7. Free Swell Index

Free swell index is a measure of the ability of a soil to absorb water and increase in volume without any external pressure. It is commonly used in geotechnical engineering to evaluate the swell potential of soils and to assess their suitability for various construction applications, such as foundation design, earthworks, and road construction.

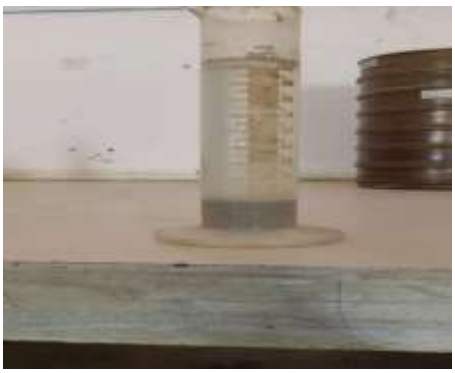


Figure7.1: Free Swell Index(60%)

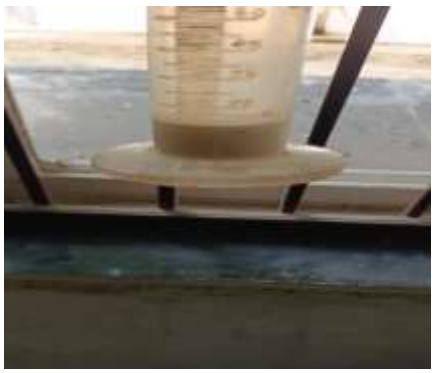


Figure 7.1A: Free Swell Index(50%)

8. Standard Proctor Test

The Standard Proctor Test, also known as the Proctor Compaction Test, is a laboratory test commonly used in geotechnical engineering to determine the maximum dry density and optimum moisture content of a soil. The test is based on the principle that the compaction of a soil sample into a standard mold under controlled conditions can be used to simulate the densification that occurs when a soil is subjected to the weight of an overlying structure.

Figure8.1: Standard Compaction Test

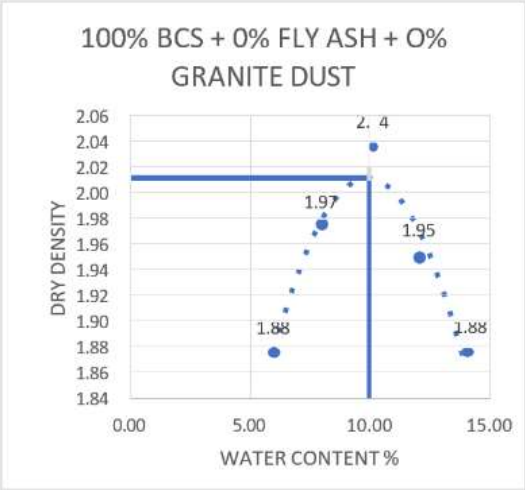


Chart 8.1

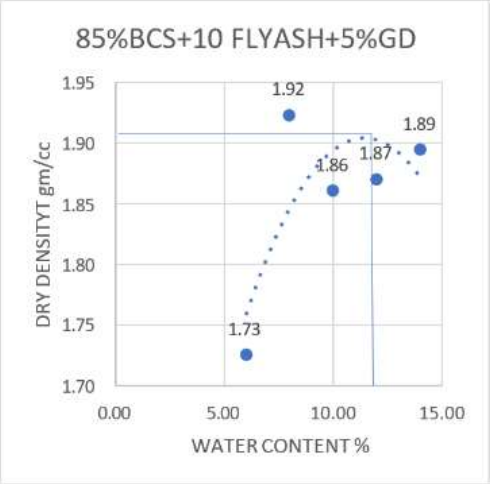


Chart 8.1 (a)

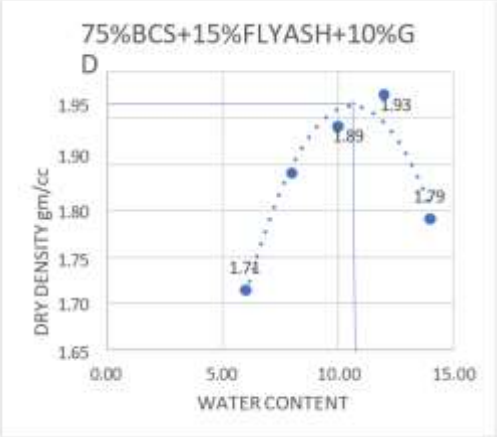


Chart 8.1(b)

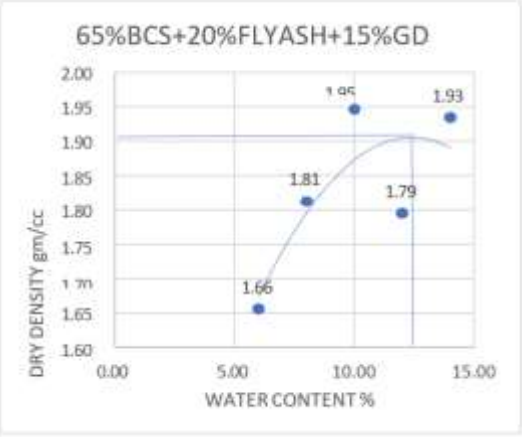


Chart 8.1(c)

9. Unconfined Compressive Strength

Unconfined compressive strength (UCS) is a measure of the strength of a soil or rock material when compressed between two parallel plates without any confinement or lateral support. It is an important parameter in geotechnical engineering, used to evaluate the stability of soil or rock masses and to design foundations, retaining walls, and other structures.

The unconfined compressive strength test involves placing a cylindrical sample of soil or rock in a testing machine and applying a vertical load at a constant rate until the sample fails. During the test, the sample is not confined laterally and is allowed to bulge outward as it is compressed. The maximum load that the sample can withstand before it fails is recorded, and the unconfined compressive strength is calculated as the maximum load divided by the cross-sectional area of the sample.

Figure9.1: Unconfined Compressive Strength

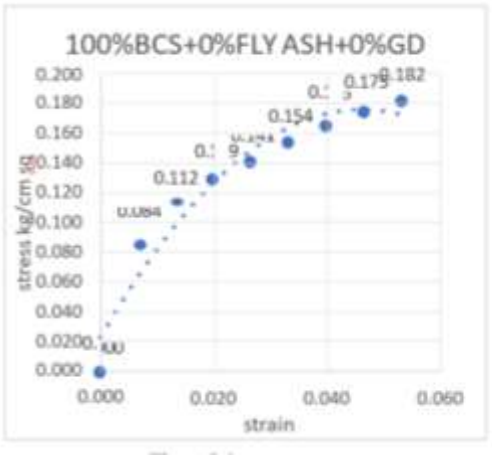


Chart 9.1

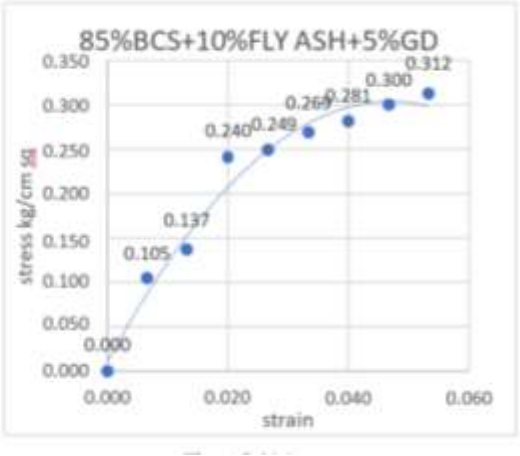


Chart 9.1(a)

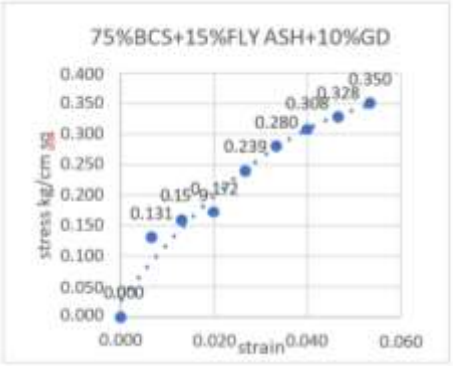


Chart 9.1(b)

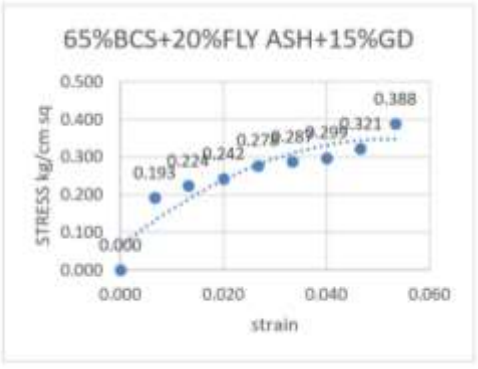


Chart 9.1(c)

Data Sample Values for Various Tests Adding Admixtures

Sl.no	Laboratory Tests	BCS	5% -10%	10%-15%	15%- 20%
01	Liquid limit %	50%	31.5%	30%	27.27
02	Plastic limit %	25	22.2	20	14.28
03	Plasticity index %	25	9.28	10	12.99
04	Optimum moisture content (OMC) %	10	8	12	10
05	Maximum dry density gm\cc	2.02	2.06	1.9	1.91
06	Unconfined compressive strength test (UCS)	0.446	0.454	0.483	0.53
07	Cohesion kg\cm^2	0.227	0.387	0.435	0.482

Table 9.1

CONCLUSIONS

From the experimental study we can conclude that;-

1. Soil sample is classified as per the Indian Standard Soil Classification System (ISSCS) as Clayey Sand (SC)

2. Both the liquid limit and plastic limit values of the mixed soil,Fly Ash + Granite Dust mixtures decreases with increase in percentage of FlyAsh + Granite dust

3. Plasticity Index values of soil, FlyAsh + Granite dust Mixtures are less than that of the soil alone

4. The OMC decreases at 5%GD+10%FA and increases slightly with increases in FlyAsh + Granite Dust mixtures.

5. Maximum Dry Density decreases with increase in percentage of FlyAsh + Granite Dust Mixtures

6. UCC value also increases because the gains in strength due to the addition of FlyAsh + Granite dust Mixtures

7. Cohesion of the soil sample has been increased with percentage increase in FlyAsh + Granite Dust Mixtures

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