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Innovative Soil Stabilization by using Fly Ash and Plastic Strips for Black Cotton Soil Improvement

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Abstract: In civil engineering construction, soil is essential, and inadequate soil characteristics can result in serious structural problems. The extremely expansive black cotton soil, which is primarily found in South India, presents significant difficulties since it shrinks in dry conditions and swells during the rainy season. Pavements, buildings, and foundations sustain significant damage as a result of these volume fluctuations. Stabilization methods are necessary to improve the black cotton soil's engineering qualities. This study investigates the use of fly ash and plastic strips to stabilize black cotton soil. Fly ash, an industrial by-product from thermal power plants, is incorporated at varying percentages of 5%, 10%, 15%, and 20% to determine the optimal dosage for improving soil strength. Once the optimal fly ash percentage is identified, plastic strips of 20mm × 20mm dimensions are added at 0.25%, 0.5%, 0.75%, and 1% by weight of the soil. The inclusion of plastic waste addresses its disposal challenges while enhancing soil properties. The stabilization process aims to improve soil strength, reduce its expansive nature, and mitigate infrastructure damage Fly ash and plastic strips work together to improve black cotton soil in an economical and environmentally responsible way, encouraging sustainability in building. This research contributes to more robust and long-lasting infrastructure by shedding light on the possible use of industrial waste for soil stabilization.

Keywords: *Black Cotton Soil, Fly Ash, Plastic Strips.*

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I. INTRODUCTION

Mostly found in central and southern India, black cotton soil is a cohesive, extremely expansive soil. It is distinguished by its black and mild to dark grey hues. Its propensity to expand during the wet season and contract during the dry one is one of its major disadvantages, which makes construction extremely difficult. The swelling results in uplift pressure, leading to foundation heaving, plinth beam displacement, and surface deformation in roads and canals. Conversely, shrinkage during the summer season induces cracks in structural elements such as walls, slabs, floors, and plinth protection because of its extremely low bearing capacity and great compressibility, this type of soil makes construction challenging, particularly for lightly loaded structures that are more vulnerable to damage from variations in soil volume. But despite its technical difficulties, black cotton soil is extremely fertile and ideal for farming. It is rich in minerals and nutrients, offering excellent drainage capabilities, making it ideal for growing crops such as cotton, paddy, sugarcane, black gram, and corn. The soil derives its name from its historical association with cotton cultivation.

Given its poor load-bearing capacity, construction on black cotton soil requires special foundation techniques. Suitable foundation systems include mat or raft foundations, deep foundations with spread footings or wall footings, and under-reamed piles to mitigate structural distress. Proper stabilization methods are essential to enhance soil performance, ensuring structural stability and longevity.

II. TYPES OF BLACK COTTON SOIL

There are three different types of black cotton soil: shallow, medium, and deep. Because of its rapid rate of swelling and shrinkage, the soil has continued to be an inappropriate site for the majority of civil engineering projects. One form of soil that is observed to be less than 30 cm thick is called "Shallow Black Soil." It can be found in Nagpur, Satara (Maharashtra), and the Satpura Hills (Madhya Pradesh) in Karnataka. Cotton, wheat, gram, and rice can all be grown in this kind of soil. 2. Medium Black Soil: this type of soil has a thickness of 30 to 100 cm. A greater portion of Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu, and Andhra Pradesh are covered by it. 3. Deep Black Soil: The soil is over a meter thick.

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III. MATERIALS AND METHODOLOGY

➢ *Black Cotton Soil*

Black cotton soil is widely found in Andhra Pradesh and is highly fertile, making it ideal for agriculture. However, its poor bearing capacity and significant shrink-swell behavior pose serious challenges for civil engineering construction. The soil's tendency to expand during the rainy season and shrink in dry conditions leads to structural cracks, affecting buildings, roads, and other infrastructure.

With increasing population, rapid industrialization, and limited land availability, construction on black cotton soil has become inevitable despite its low shear strength. Several ground improvement measures, including soil stabilization and reinforcing, must be used to increase soil stability and guarantee the longevity of structures. These methods improve soil strength, reduce expansion-related damage, and make construction more reliable in areas dominated by black cotton soil.

➢ *Fly Ash*

A byproduct of burning coal, fly ash is made up of tiny particles that are expelled from boilers that burn coal. Bottom ash is the heavier ash that collects at the combustion chamber's bottom. Fly ash is captured by electrostatic precipitators or filtration systems in contemporary power plants prior to it reaching the chimneys. Depending on the coal source, its composition varies, but in general, it contains trace metals including chromium and arsenic as well as silicon dioxide (SiO_2), calcium oxide (CaO), and aluminum oxide (AlO_3). In the past, fly ash was released into the atmosphere, posing serious health risks and air pollution. Engineers are creating creative ways to use it in order to lessen this. Nowadays, fly ash is a common lightweight aggregate in construction materials used in civil engineering. This strategy not only.

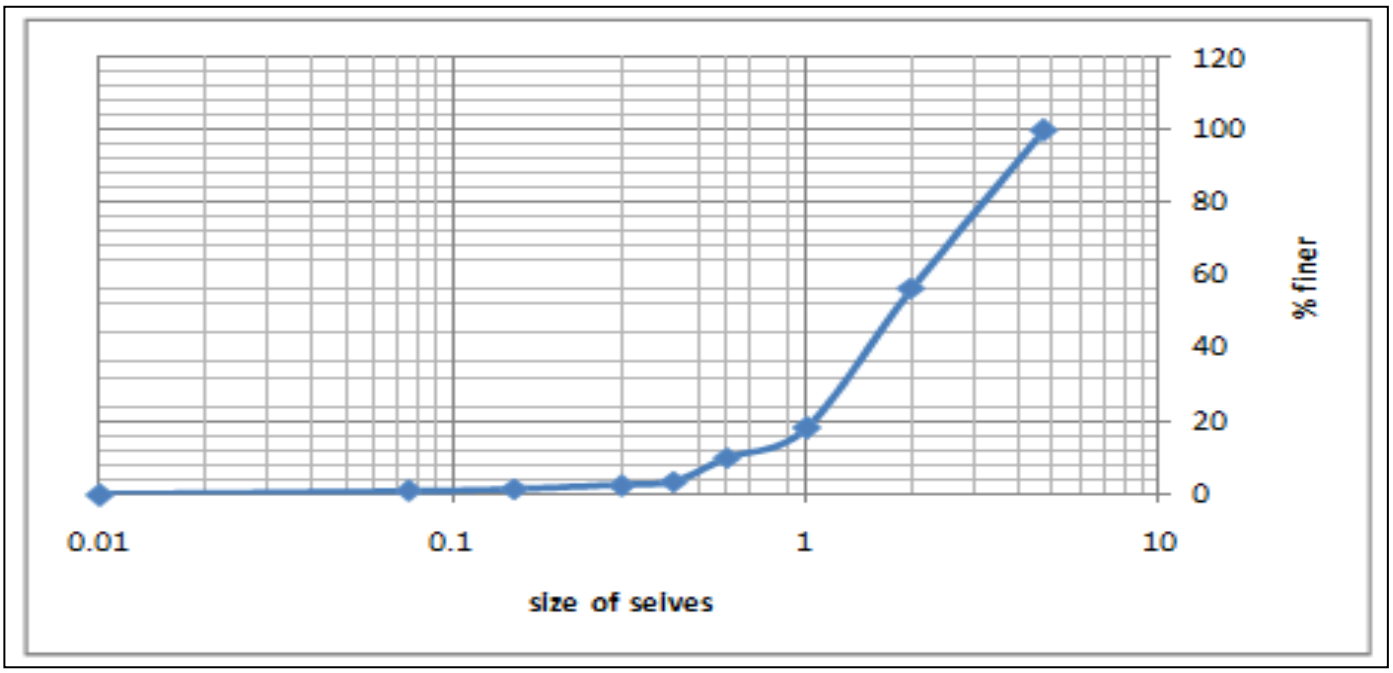
➢ *Plastic*

Plastics are synthetic or semi-synthetic materials made from organic polymers with high molecular mass, often derived from petrochemicals. Their low cost, water resistance, ease of production, and versatility make them widely used in various industries. Plastics have largely replaced traditional materials like wood due to their durability and functionality. In developed nations, about one-third of plastic is used in packaging, with similar usage in piping and plumbing. Other applications include automobiles, furniture, and toys. In India, packaging accounts for nearly 40% of total plastic consumption. Despite their advantages, plastics pose environmental concerns due to their slow decomposition rate. By the late 20th century, recycling emerged as a key solution to mitigate plastic waste. Plastics possess superior properties, classified into physical and chemical

➢ *Method of Mixing*

- The fly ash, which is supposed to make the soil stronger, is added in four different percentages: 5%, 10%, 15%, and 20% of the soil's mass. The percentage by mass is the mass of fly ash divided by the mass of the soil sample.
- Plastic strips are used as an additive in percentages of 0.25%, 0.5%, 0.75, and 1% to get the ideal percentage of fly ash blended black cotton soil.

IV. EXPERIMETALRESULTS AND DISCUSSIONS



Graph 1: Particle Size Distribution of Black Cotton Soil

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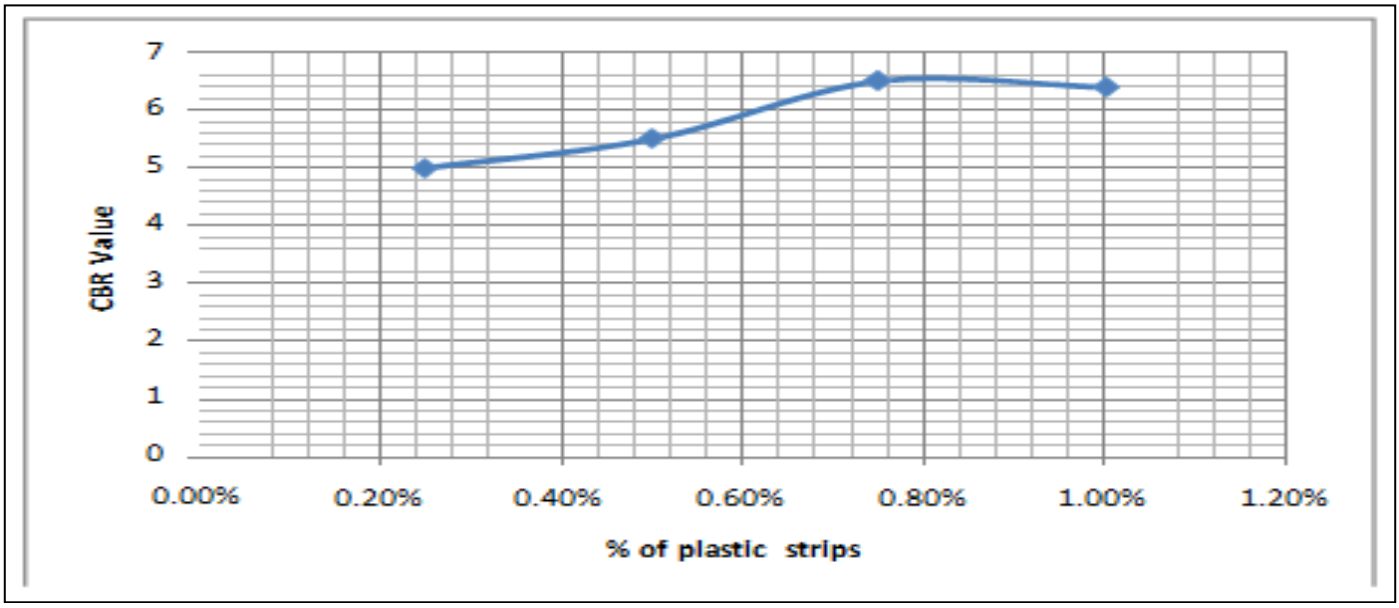
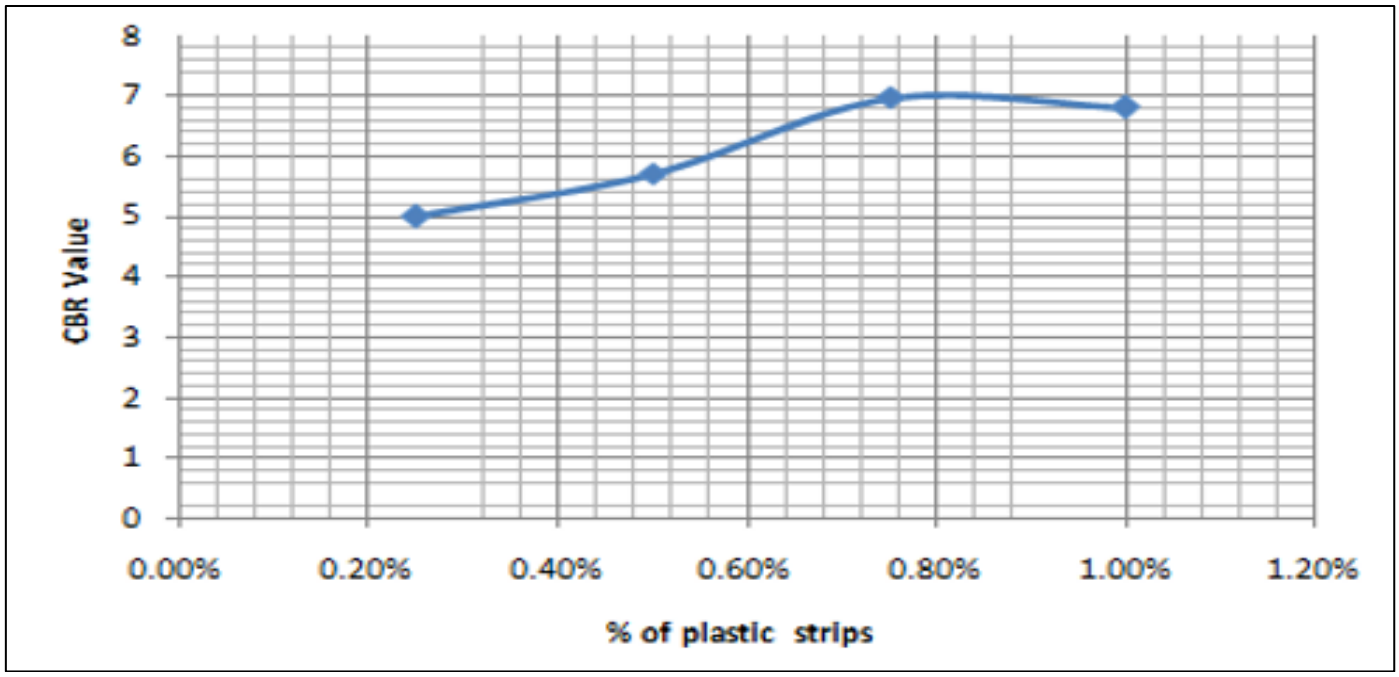


Graph 2: CBR of Black Cotton Soil Fly Ash+ Plastic Strips@ 5MM Penetration



Graph 3: CBR of Black Cotton Soil Fly Ash+ Plastic Strips @ 5MM Penetration

Table 1: Test Results of Black Cotton Soil with Fly Ash

S. NO	Property	Fly Ash Proportions				
		0%	5%	10%	15%	20%
1	Specific Gravity	2.56	1.86	1.723	1.503	1.29
2	Liquid Limit	22.12%	37%	46.05%	59.47%	62.49%
3	Plastic Limit	20%	28.50%	32.35%	41.70%	56.50%
4	Plasticity Index	2.12%	8.9%	13.7%	17.77%	5.99%
5	OMC	12%	12%	12%	12%	12%
6	MDD	1.59grms/cc	1.7grms/cc	2.15grms/cc	2.161grms/cc	2.01grms/cc
7	Swelling Index	70%	65%	63%	58%	30%
8	Permeability	0.00198mm/s	0.00175mm/s	0.00148mm/s	0.00124mm/s	0.00179mm/s
9	CBR	3.59	3.23	3.545	5.285	3.58

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Fig 1: Fly Ash

Table 2: Test Results of Black Cotton Soil with Fly Ash & Plastic

S. NO.	Property	Fly Ash Proportions=15%			
		Plastic Strips Proportions			
		0.25%	0.50%	0.75%	1.00%
1	CBR@2.5mm	5	5.5	6.5	6.4
2	CBR@5mm	5	5.7	6.95	6.8
3	CBR Value	5	5.6	6.732	6.6

V. CONCLUSION

The main objective of this project is to study the role of fly ash with plastic strips in black cotton soil, and an attempt has been made in this project to mix the fly ash with black cottonsoil in increasing proportions such as 5%, 10%, 15%, 20% and later the plastic strips were added to the optimum fly ash mixed black cotton soil with an increasing percentages of 0.25%, 0.5 0.5%,0.75%, and 1.0% and various test are conducted to determine the various properties like OMC, MDD, CBR, LL, PL.

➢ *From the Final Results that we have Obtained we can Observe the Following:*

- The specific gravity of soil is decreases with the increase of fly ash proportion to
- The liquid limit value of the soil is increasing with the increase of fly as proportionto the soil.
- The plastic limit value of the soil is increasing with the increase of fly ash proportion.
- We got the maximum plasticity index value at 15% of fly ash.
- We got the maximum dry density of soil at 12% of optimum moisture content and15% of fly ash.
- The values of permeability and swell index are decreasing with the addition of fly ash.
- When it comes to CBR value we got the max CB value at 15% of fly ash proportion.

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