Stabilization of Black Cotton Soil through Zinc Slag

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Abstract - *The development of a nation's economy is the goal of industrialization. The environmental contamination caused by the byproducts and waste materials produced throughout the process is a key negative aspect among many others that are ignored in this process of economic progress. Since raw materials are at the heart of industrialization, many businesses rely heavily on non-renewable resources. As a result, non-renewable trash and byproducts are being produced at an increasing rate. One such hazardous waste substance is zinc slag. The zinc ore is melted at very high temperatures in the blast furnace to produce zinc slag. Globally, expanding soils and black cotton soil are major issues. It is regarded as a natural hazard because of its ability to expand and contract and the considerable harm it may do to buildings. But if the soil is adequately stabilized and maintained, these risks may be avoided. In order to stabilize the black cotton soil, this study uses modest amounts of fly ash and zinc slag to act as a binding agent between the slag and the soil.*

Key Words: Black cotton soil, Fly Ash, Zinc Slag, Stabilization, Industrialization.

1.INTRODUCTION

Black Cotton Soil is a cohesive soil. For civil engineers, it is a challenging or troublesome soil. It has the ability to swell during wet seasons and contract throughout the summer. It presents issues in both scenarios.

When the Black Cotton Soil expands during the rainy season, the structure experiences uplift pressure, which causes heave in the foundations, plinth beams, first floors of buildings, canals, road surfaces, etc. When the soil contracts during the summer, walls, slabs, plinth protection, floors, etc. develop cracks due to shrinkage.

Due to a larger amount of clay, Black Cotton soil expands during the wet season. When it rains, it swells, and when it shrinks in the summer, it fractures. The fissures are typically between 0.5 and 2 metres deep and 100 to 150 millimetres broad.

The Black Cotton soils have a very poor bearing capacity and are very compressible. The soils have excellent qualities for shrinkage and swelling. The soils have a very weak shear strength. Expansive soil is another name for black cotton soil.

1.1 Need of the study

The traditional techniques for stabilising the black cotton soil include largely applying lime and brick powder to the soil. Although expensive, these traditional techniques are efficient. These two materials range in price from 8 to 15 rupees per square metre, depending on the material's grade, whereas zinc slag is priced between 2 and 5 rupees per kilogramme. As a result, this approach is not only efficient but also cost-effective. Additionally, by effectively using the zinc slag, this process minimize any negative environmental effects. This strategy of stabilising black cotton soil is thus superior to traditional ways from both an economic and environmental standpoint.

1.2 Black Cotton Soil

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Fig -1: Black cotton soil

The extensive soil deposits are known among the Indians as "black cotton dirt."

Black cotton soils cover a significant portion of central India as well as a portion of southern India, including Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, South Gujarat, and Uttar Pradesh. The area covered is around 3,000 square kilometers. Basalt or trap rocks have been used to form these soils. The soils in this area are ideal for cultivating cotton.

1.3 Zinc Slag

In India, it has become popular to utilise industrial waste in a variety of engineering projects.

Fig -2: Zinc Slag

This is necessary because of the disposal issues it raises. The most often utilised waste products in the building sector today are fly ash, copper slag, and zinc slag. These wastes build up in large numbers and are deposited on expensive land, wasting valuable cultivable land. An inexpensive alternative to cement mixing, road building, embankment filling, and soil stabilisation is to mix these wastes with the current soil type rather than fully removing it and replacing it with a different soil type. The use of zinc slag in soil stabilisation not only makes it easier to dispose of zinc slag in large quantities, but it also has major technical and financial advantages.

2. Objectives of the study

To minimize the cost of the process of the stabilization of black cotton soil.

To utilize the zinc slag and prevent it from causing environmental hazards.

To replace the conventional methods with a more economical method.

3. Literature review

Differential settlements, inadequate strength, and excessive compressibility are challenges when building on weak or soft soils. Because they are weak, clayey soils will not adequately sustain a pavement, which will eventually influence how well it performs and how long it lasts. Clayey soil has an impact on pavement design and construction as well, increasing construction costs and hastening pavement breakdown. To increase the load bearing capacity of soil, a number of strategies are available, including soil stabilisation and supplying reinforcement. The successful use of industrial wastes as a stabiliser is made possible by soil stabilisation, one of the modification used to enhance the geotechnical qualities of soil, which has grown to be a key practise in construction engineering. Because it is accessible and adaptable, this method is growing in popularity. The process of stabilising waste materials allows for the creation of low-cost road building.

4. Results

The tests conducted during the whole experiment yielded the following findings:

Table -1: Virgin Black Cotton Soil

Item No.	Test Name		Unit	Test Result	Method of Testing
1	Atterberg's Limit	Liquid Limit	%	49.8	I.S.2720 Part 5-1985
		Plastic Limit	%	26.9	
		Plasticity Index	%	22.8	
2	Grain Size Analysis	Gravel (> 4.75mm)	%	0	I.S 2720-Part 4-1985
		Sand (4.75 - 0.075mm)	%	5	
		Silt & Clay (<0.075mm)	%	95	
3	Free Swell Index		%	36	I.S.2720 - Part 40 - 1977
4	Modified Proctor Density	Maximum Dry Density	gm/cc	1.834	I.S.2720 Part 8 -1983
		Optimum Moisture Content	%	13.7	
5	C.B.R (Soaked)		%	3.1	I.S.2720 Part 16-1987
6	Specific Gravity		-	2.64	IS: 2720 (Part-3) - 1980
7	Triaxial Test	C	kg/cm2	0.64	I.S.2720 Part 11-1992
		Ø	Degree	1	
8	Unconfined Compressive Strength		kg/cm^2	3.15	I.S 2720 Part 10 -1991

Item No.	Test Name		Unit	Test Result	Method of Testing
1	Modified Proctor Density	Maximum Dry Density	gm/cc	1.953	I.S.2720 Part 8 -1983
		Optimum Moisture Content	%	11.1	
2	C.B.R (Soaked)		%	3.7	I.S.2720 Part 16-1987
3	Triaxial Test	C	kg/cm2	1.94	I.S.2720 Part 11-1992
		Ø	Degree	24	
4	Unconfined Compressive Strength		kg/cm^2	4.53	I.S 2720 Part 10 -1991

5. CONCLUSIONS

In this study, diverse combinations of various ratios of black cotton soil, fly ash, and zinc slag were subjected to the Modified Proctor test, California Bearing Ratio test, Triaxial test, and Unconfined Compressive Strength testing.

As a consequence of the obtained findings, the Black Cotton soil's Unconfined Compressive Strength improved from 3.15 kg/cm3 to 4.53 kg/cm3, and the California Bearing Ratio increased from 3.1% to 3.7%.

The mixture of 75% Black Cotton Soil, 15% Zinc Slag, and 10% Fly Ash produced the best results.

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