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Expermental Study of Stabilization of B.C. Soil by Using Slag and Glass Fibers

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Abstract: **Stabilization of black cotton soils with various additives has also attained lot of success and due to rapid industrialization throughout the world; the production of huge quantity of produced waste materials creates not only the environmental problem but also the disposal hazards. Many procedures have been developed to improve the mechanical properties of soil by incorporating a wide range of stabilizing agents, additives. In this paper, an attempt had been made to utilize industrial wastes such as blast furnace slag and glass fibres as stabilizing agents. The effect of blast furnace slag and glass fibres on certain properties of soil such as Optimum moisture content (OMC), Maximum Dry Density (MDD), Differential free swell and California Bearing Ratio (CBR) had been studied. It has been established by experiments conducted on the samples by using blast furnace slag, 6mm and 12mm glass fibres A series of CBR test were carried out on black cotton soil by varying percentage of blast furnace slag (0%, 5%, 10%, !5%, 20% 25%, 30%)and glass fibre with different length (6mm & 12mm) and proportions (0%, 0.25% 0.50%, 0.75%, 1.00% and 1.25% by weight of dry soil with optimum percentage of slag). Results of various test demonstrated the inclusion of blast furnace slag and glass fibre in soil with appropriate proportion improved strength and Swelling behaviour of soils.**

Keywords: **Blast furnace slag, Glass fibre, Differential free swell, Maximum Dry Density, California Bearing ratio.**

1. INTRODUCTION

Foundations in expansive soils, popularly known as black cotton soils in this country, undergo alternate swelling and shrinkage upon wetting and drying due to seasonal moisture fluctuations. Usually moisture and water vapor migrates from the high temperature zones around the building. The difference in water contents between the interior and the exterior zones of the building causes uplift of the interior portion and results in mound – shaped heave of the floor of the building. This induces hogging moments, which are more detrimental to the safety of the structure than sagging moments. Severe cracking might result in the walls of the structure as a consequence. Black cotton soils are a worldwide problem that creates challenges for Civil Engineers. They are considered as potential natural hazard, which can cause extensive damage to structures if not adequately treated. The disadvantages of black cotton soil can be overcome by stabilizing with suitable material. Development of any country can be closely monitored by the improvement in infrastructural facilities in which transportation plays a key role. The quality and durability of a pavement is greatly affected by the type of sub grade soil over which such pavements are to be constructed. Pavement structure response is very sensitive to the characteristics of the sub grade which provides the support base for such pavement structure. Problems associated with pavement construction further become far more critical, particularly in regions where the sub grade consists of expansive soils. In India these soils cover about 0.8x106 Sq. Km. area which is more than one fifth of its surface area and extend over the states of Maharashtra, Gujarat, parts of Uttar Pradesh, Madhya Pradesh, Rajasthan, Andhra Pradesh and Tamil Nadu. In recent years reinforced earth technique has been gaining popularity in the field of geotechnical engineering due to its highly versatile and flexible nature and is being widely used for the construction of retaining walls, embankments, earth dams, foundation beds for heavy structures on soft grounds, viaducts and other applications.

1.1 Soil Stabilization

The term soil stabilization means the improvement of the stability or bearing power of a poor soil by the use of controlled compaction; proportioning and the addition of suitable admixtures or stabilizers. Soil stabilization deals with mechanical, physico-chemical and chemical methods to make the stabilized soil serve its purpose. The stabilization process, essentially involve excavation of the in-situ soil, treatment to the in-situ soil and compacting the treated soil .As the stabilization process involve excavation of the in-situ soil, this technique is ideal for improvement of soil in shallow depths such as pavements .Methods of stabilization may be grouped under two main types:

(a) modification or improvement of a soil property of the existing soil without using any admixture and (b) modification of the properties with the help of admixture. The examples of the first type are compaction and drainage, which improve the inherent shear strength of soil. The examples of the second type are stabilization with admixtures like cement, lime, bitumen, fly ash and chemicals. Deep soil deposits are stabilized by electrical methods, grouting, freezing etc. The use of lime, cement and bitumen has become common as stabilizing agents. The soil chosen for the purpose of the present study is a Black Cotton soil and the stabilizers used are Stone Dust and polypropylene Fibers.

Need of Investigation

Soil is the basic material for construction of road. When black cotton soil which is having poor engineering properties is encountered, a civil engineer has following options
1) Finding new site for construction
2) Redesign the structure
3)Removing poor soil and replace it
4) Improving the engineering properties of locally available soil

In developing countries like India, where industrial growth is very high and the disposal of waste is a problem, use of the waste for improving engineering properties of soil will be eco friendly and economical solution

1.3 Objectives of the study

Objectives of the study are

a) To study the effect of blast furnace slag at varying percentage on properties of black cotton soil.
b) To study effect of 6mm & 12mm glass fibers with varying percentage on black cotton soil.
c) To study effect of blast furnace slag & 6mm glass fibers with varying percentage on black cotton soil.
d) To study effect of blast furnace slag & 12 mm glass fibers with varying percentage on black cotton soil.

2. RESEARCH PERFORMED BY INVESTIGATORS

Gyanen Takhelmayum, savitha.A.L & Krishna Gudi [1] had been studied experimental studies on black cotton soil stabilization using fine and coarse GGBS and they were study of soil with varying percentage of slag and It was found that with the increase in water content the dry density also increases up to 20-30% moisture content and with further increase in water content the dry density increases gradually . This variation in density is primarily due to chemical composition, glass phase content, particle size distribution and surface morphology. The increase in the maximum dry unit weight with the increase of the percentage of GGBS mixture is mainly due to high specific gravity and immediate formation of cemented products by hydration which increases the density of soil.

K. Suresh, V. Padmavathi, Apsar Sultana [2] had been studied experimental Study of Stabilization of black cotton soil by using stone dust and fibers and they were found that There is increase in unconfined compressive strength with addition of stone dust and fibers and the increase in strength with addition of optimum stone dust and fibers are more compared to only stone dust and fibers.

Chandra, S., Viladkar M. N. and Nagrale P.[3] had been studied In present study, the relative gain in strength and ductility was evaluated by conducting a series of unconfined compression strength tests (UCS). Specimens of soil fly ash mixtures were tested with 0, 0.5, 1.0 and 1.5 percent polypropylene fibers with various lengths of fibers.

3. MATERIALS

3.1 Blast Furnace Slag (BFS): Blast furnace slag (BFS) is a nonmetallic co product produced in the process of iron production. It consists primarily of silicates, alumino silicates, and calcium-alumina-silicates. The molten slag, which absorbs much of the sulfur from the charge, comprises about 20 percent by mass of iron production. Different forms of slag product are produced depending on the method used to cool the molten slag. These products include air-cooled blast furnace slag (ACBFS), expanded or foamed slag, pelletized slag, and granulated blast furnace slag.

1.) Air-Cooled Blast Furnace Slag (ACBFS): If the liquid slag is poured into beds and slowly cooled under ambient conditions, a crystalline structure is formed, and a hard, lump slag is produced, which can subsequently be crushed and screened.

2.) Expanded or Foamed Blast Furnace Slag(EBFS): If the molten slag is cooled and solidified by adding controlled quantities of water, air, or steam, the process of cooling and solidification can be accelerated, increasing the cellular nature of the slag and producing a lightweight expanded or foamed product. Foamed slag is distinguishable from air-cooled blast furnace slag by its relatively high porosity and low bulk density.

3.) Pelletized Blast Furnace Slag (PBFS): If the molten slag is cooled and solidified with water and air quenched in a spinning drum, pellets, rather than a solid mass, can be produced. By controlling the process, the pellets can be made more crystalline, which is beneficial for aggregate use, or more vitrified (glassy), which is more desirable in cementitious applications. More rapid quenching results in greater vitrification and less crystallization.

4.) Granulated Blast Furnace Slag (GBFS): If the molten slag is cooled and solidified by rapid water quenching to a glassy state, little or no crystallization occurs. This process results in the formation of sand size (or frit-like) fragments, usually with some friable clinker like material. The physical structure and gradation of granulated slag depend on the chemical composition of the slag, its temperature at the time of water quenching, and the method of production. When crushed or milled to very fine cement-sized particles, ground granulated blast furnace slag (GGBFS) has cementitious properties, which make a suitable partial replacement for or additive to Portland cement.

3.2 Glass Fibers

In recent years the uses of fibers in various fields have gained much importance. Several researches on soil reinforced fibers have been reported some amongst are shown below. The research on fiber-reinforced soils demonstrated that this material might be a practical and cost In comparison with systematically reinforced soils, randomly distributed fiber reinforced soils exhibit some advantages.

Randomly distributed fibers offer strength isotropy and limited potential plane of weakness that can develop parallel to oriented reinforcement fibers are used to evaluate a methodology for preventing crack developments in clays due to desiccation and. It is suggested that the reinforcing fiber concept might be improved if longer fibers are used. Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time, all glass fiber had been manufactured as staple (that is, clusters of short lengths of fiber).

4. METHOD OF STABILIZATION

(1)Mechanical method of Stabilization

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

(2) Additive method of stabilization

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two methods;

a) Oriented fiber reinforcement-

The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation. Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

b) Random fiber reinforcement-

This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties.

Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

5. EXPERIMENTAL STUDY

5.1 Test Materials

5.1.1 Black Cotton Soil

Soil for the work was collected from Jalna city. Tests were carried out to determine the various properties of soil and results are tabulated in table 1 given below;

Sr No	B.C. Soil Property	Value	Relevant IS Codes
1	Specific Gravity	2.66	IS 2720 Part III
2	Liquid limit	61.26 %	IS 2720 Part V
3	Plastic limit	25.07 %	IS 2720 Part V
4	Plasticity index	36.19 %	IS 2720 Part V
5	Free swell index	23.08	IS 2720 Part XI
6	Max Dry density	1.498 g/cm3	IS 2720 Part VIII
7	Optimum moisture content	20.52 %	IS 2720 Part VIII
8	California bearing ratio (Soaked)	1.27	IS 2720 Part XVI

5.1.2 Slag

The slag used in the present study was collected from shree om steel industry, Jalna.

5.1.3 Glass fibers

Glass fibers purchased from Roff Point, Aurangabad, have been used in the investigation.

5.2 Tests and Results on soils

For observation of effect of Slag and glass fibers on Black Cotton Soil, q Following Engineering properties are determined by performing the experiment by adding these additives at different percentages with soil.

1. Differential free swell test
2. Maximum Dry Density and optimum moisture content (MDD & OMC)
3. California Bearing Ratio (California Bearing Rati

6. MIX PROPORTION

Soil with 5%, 10%, 15%, 20%, 25%, 30% by weight of soil .

Soil with 25% slag & 6 mm length glass fibre at 0.25%, 0.5%, 0.75%, 1% & 1.25%.

Soil with 25% slag & 12 mm length glass fibre at 0.25%, 0.5%, 0.75%, 1% & 1.25%.

Table 3 Addition of Clayey soil + slag
Slag—0%, 5%, 10%, 15%, 20%, 25%, 30%

Mix proportion	OMC (W%)	MDD(gm/cc)	CBR(%)
Plain B.C.Soil	20.52	1.498	1.27
Soil + Slag (5%)	19.84	1.535	1.75
Soil + Slag (10%)	18.14	1.583	2.07
Soil + Slag (15%)	17.51	1.608	2.50
Soil + Slag (20%)	17.18	1.664	3.02
Soil + Slag (25%)	16.22	1.695	3.59
Soil + Slag (30%)	15.96	1.703	3.98

Addition of Slag (25%) in soil as optimum percentage because of its cost effectiveness and very less difference in MDD was observed .

Table 4 Addition of clayey soil +Slag (25%) + Glass fibre (6mm)
Glass fibre (6mm)----0.25%, .5%, .75%, 1%, 1. 25%

Mix proportion	OMC W%)	MDD(gm/cc)	CBR(%)
Soil + slag(25%) + fibre (0.25%)	15.94	1.699	3.59
Soil + slag(25%) + fibre (0.5%)	15.11	1.720	3.82
Soil + slag(25%) + fibre (0.75%)	14.88	1.732	3.98
Soil + slag(25%) + fibre (1%)	14.24	1.742	4.38
Soil + slag(25%) + fibre(1.25%)	13.44	1.754	4.14

Table 5 Addition of clayey soil +Slag (25%) + Glass fibre (12mm)
Glass fibre (12mm) ---- 0.25%, 0.5%, 0.75%, 1%, 1. 25%

Mix proportion	OMC W%)	MDD(gm/cc)	CBR (%)
Soil + slag(25%) + fibre (.25%)	15.94	1.699	3.66
Soil + slag(25%) + fibre (.5%)	15.11	1.720	3.98
Soil + slag(25%) + fibre (.75%)	14.88	1.732	4.14
Soil + slag(25%) + fibre (1%)	14.24	1.742	4.14
Soil + slag(25%) + fibre(1.25%)	13.44	1.754	3.82

7. CONCLUSIONS

This paper investigates the effect of introducing waste slag and glass fibers as sustainable additives to strengthen the black cotton soil The following conclusions are drawn:.

1. Mixing of soil with varying percentage of slag lead to decrease in optimum moisture content and to increase in maximum dry density.
2. Mixing of soil with varying percentage of slag lead to decrease in swelling behavior of soil and CBR value increases for soaked condition.

3. Mixing of soil with optimum percentage of slag and varying percentage of 6mm glass fibre lead to an increase in maximum dry density and CBR value increases for soaked condition.

4. Mixing of optimum percentage of slag and varying percentage of 12mm glass fibre soil lead to an increase in maximum dry density and CBR value increases for soaked condition

5. Mixing of soil with 12mm fibre with soil had been better performance as compared to 6mm fiber

And it is concluded that CBR value increases with increase in length of fibre.

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