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COMPARATIVE STUDY OF BLACK COTTON SOIL AND STABILIZED BLACK COTTON SOIL BY USING STEEL SLAG AND PLASTIC

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ABSTRACT

As we know that black cotton soil always has low bearing capacity and high swelling and shrinkage characteristics. According to Wyoming office of homeland security (2014) the USA loses about 2.3 billion/ years due to structural damage (including building, road, pipelines, and other structures) so it is necessary to stabilized the black cotton soil using the different admixture to overcome these circumstances. According to Zumrawi and Khalil the daily production of steel is estimated as 15-20 tons. While manufacturing of steel or iron lot of waste generated i.e., Steel slag. The disposal of Steel Slag in the land field may cause lots of environmental issue. For avoid such type of issue steel slag use as a soil stabilizer. On the other hand plastic waste increases day by day and it has a slow rate of decomposition when plastic waste left on a soil without any treatment. It release toxic substances which can directly effect on groundwater table. To overcome such type of occurrence, we can use plastic as an admixture in a soil stabilization. By looking at all these issues steel slag and plastic are used as a soil stabilizer to improve the engineering property of black cotton soil.

Keywords: Black cotton soil, Stabilization, Steel slag, Plastic strips, Testing.

I. INTRODUCTION

- **Black Cotton Soil**

The name of this soil is formed, from its physical property, like a color is black and it is more suitable for cotton farming, that is why its name formed black cotton soil.Black Cotton Soil is a cohesive soil. It is considered difficult or problematic soil for civil engineers. It possesses the characteristics of swelling during the rainy and shrinking during summer. In both situations, it possesses difficulties. The structure has uplift pressure and generates heave in the foundations, plinth beams, ground floors of the buildings and canals, roads surfaces, etc., and on shrinkage in the summer season, cracks are created in walls, slabs, plinth protection, floors, etc. The change in size is 20 to 30%. A large part of central India and a part of South India covering Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, South Gujarat, and Utter Pradesh is covered with Black Cotton Soils. The covering area is approximately 3,00,000 sq. km.

Properties of black cotton soil:

- ❖ It has good moisture holding capacity.
- ❖ They formulate deep cracks during the hot climate which enables the adequate aeration of the soil.

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- It has high swelling and shrinkage property.
- Black Cotton Soil is fine textured and clay in nature.
- It has great quantities of lime, iron, magnesium, and mainly low amounts of phosphorus, nitrogen, and organic matter.
- It has high fertility.
- Black soil contains almost 50% of clay and can hold water for a long time.
- To overcome such a property of soil, soil stabilization is required.

- **Plastic**

Plastics are a wide range of synthetic or semi-synthetic materials that use polymers as a main ingredient. All plastics are said to be polymers. The word plastic was derived in Greek from the word 'Plastikos' which means 'to mould.' Fossil fuels have hydrogen and carbon (hydrocarbon) containing compounds that act as building blocks for long polymer molecules. Such building blocks are referred to as monomers, which bind together to form long chains of carbon called polymers.

Advantages of plastic:

- Its production cost is low and it is lightweight.
- It is resistant to corrosion. It can be translucent, transparent, and opaque as well.
- It is a poor conductor of heat and electricity.
- It can be used to make roads, utensils, wires, pipes etc.
- It is used in construction of buildings as well.

Disadvantages of plastic:

- The disposal of plastics products also has a significant influence on the environment.
- Plastics manufacturing also involves the addition of potentially hazardous compounds.
- Plastics are non-biodegradable.
- Plastic materials clog waterways, oceans, seas, lakes etc.
- Recycling of plastic produce toxic gases and residues which causes air and water and land pollution.

Classification of Plastic:

Broadly plastic can be divided into following two types:

- **Thermoplastics** - Thermoplastic polymer is a type of plastic. Thermoplastics are those plastics which can be moulded again and again by use of heat. Thermoplastic polymers are used in making carry bags, bottles etc. Examples polyethene, polystyrene and PVC.
- **Thermosetting plastics** - Thermosetting plastics are those plastic polymers which cannot be moulded again and again by use of heat. These are also known as thermoset polymers. Thermosetting plastics are used in making handles of utensils, switches and fire-resistant fabric etc. Examples Bakelite, melamine etc.

The accumulation of plastic objects (e.g.: plastic bottles and much more) in the Earth's environment which adversely affects wildlife, wildlife habitat, and humans, that is called as plastic waste. Day by day plastic waste are increases as the population increases. Due to this whole thing plastic are use as stabiliser for avoiding this kind of circumstances. This is the best possible way to reduce the plastic waste.

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- **Steel Slag**

Iron and steel slag that is generated as a by-product of iron and steel manufacturing processes. It can be broadly categorized into blast furnace slag and steel making slag.

A) Blast furnace slag - The slag produced from the blast furnace during production of pig iron is called blast furnace slag. It is further classified into two types:

1) Air cooled blast furnace slag (ACBFS) - ACBFS is produced by cooling the molten slag under atmospheric condition. Under controlled cooling, the slag tends to be hard and it developed pozzolanic properties.

2)Granulated Blast Furnace Slag (GBFS)and Ground Granulated Blast Furnace Slag (GGBFS) - GBFS is produced by sudden cooling or quenching of the molten slag using high-pressure water jets.

B) Steel making slag / steel slag - Steel slag is produced, during the separation of the molten steel from impurities in steel-making furnaces. The slag is a complex solution of silicates and oxides that solidifies upon cooling. Depending on the type of furnace used for manufacture of steel, the major categories of steel slag produced in India are Basic Oxygen Furnace (BOF) and Electric Arc Furnace (EAF) slag.

1) Basic Oxygen Furnace Slag (BOFS) / Converter Slag - Converter slag is cooled slowly by natural cooling and water spray in a cooling yard. Approximately, 110 kg of slag is generated for each ton of converter steel.

2) Electric arc furnace slag (EAFS)- It consists of oxidizing slag that is generated during oxidation refining, and reducing slag that is generated during reduction refining. Approximately 70 kg of electric arc furnace oxidizing slag and 40 kg of reducing slag are generated for each ton of electric arc furnace steel.

Components of steelmaking slag are limestone (CaO) and silica (SiO_2). It also contains iron oxide (FeO) and magnesium oxide (MgO). In the case of steelmaking slag, the slag contains metal elements (such as iron) in oxide form.

Uses of steel making slag: It has good hydraulic property and the large bearing capacity that's why it can be used as a road base course material. With high particle density and hardness, this slag has superior wear resistance, therefore used as an aggregate. Due to its high angle of shearing resistance, high particle density, and large weight per unit volume, it is also used as a material for civil engineering works and as a ground improvement material. Steelmaking slag used as a replacement for natural materials (beach sand, mountain sand) in sand compaction pile work.

Properties of steel slag: The particle density is 3.3 - 3.6 g/cm3, which is higher than natural stone materials, unit mass of 21 - 23 kN/m3 when moist or 14 - 16 kN/m3 in water. The size of steelmaking slag particles is in the range of 37.5 - 0.075 mm, and the angle of shearing resistance is 40 or more even when only lightly compacted. The cohesion is approximately 50 - 100 kN/m2. pH of iron and steel slag increases to 10 – 12.

Steelmaking slag products is already prescribed by JIS as materials for use in civil engineering works, because there was previously no quality standard related to environmental safety, no specific environmental considerations had been prescribed for these products. Steelmaking slag is highly regarded as a recycled material that can reduce impacts on the environment. Therefore, it is use as a stabiliser.

From the study of above things, we have to use the steelmaking slag (Converter / basic oxygen furnace slag) as well as the plastic (polyethylene terephthalate (PE) (water bottles)) as a admixture for soil stabilization.

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II. OBJECTIVES

- To identify the waste largely generated in the environment.
- To utilized the waste i.e., steel slag and plastic bottle strips as a soil stabilizer.
- To specify percentage of waste for improving the engineering property of soil.
- Main objectives of study are to increase the Bearing capacity of soil using plastic and steel slag as an admixture.
- To recognized various test is to carry out for determination of the engineering property of soil.

III. METHODOLOGY

A) Material Used -

1) **Black cotton soil -** Black cotton soil is one of major soil deposits of India. Due to its high swelling and shrinkage property, there will be a build-up pressure that will cause the crack and may destroy some parts of the structure.

2) **Steel slag -**Steel slag is a by-product of steelmaking, with remarkable properties. In terms of mineral composition, it is a calcium silicate, which makes it suitable for many applications.

3) **Plastic -**Plastics are a wide range of synthetic or semi-synthetic materials that use polymers as a main ingredient. The harmful chemicals released from plastic products throughout their entire life cycle which can cause a serious risk to humans and the environment, including when waste is not properly managed.

B) Sample Preparation-

To perform various test regarding stabilization of black cotton soil, for that purpose sample is prepared by taking 25% steel slag, 5% plastic bottle strips and remaining 70% black cotton soil. Soil sample is taken from near the JDIET Yavatmal campus. Soil is taken to the depth of 1.5m from the G.L, steel slag is taken from steelmaking industry near Yavatmal and the plastic bottle is cut into small pieces.

C) Tests To Be Carried Out -

1) Atterberg limit of the soil -

a) Liquid limit (WL) - it is a minimum water content at which soil has tendency to flow. At liquid limit, consistency of soil changes from plastic state to liquid state. At liquid limit, shear strength of soil of about 2.7KN/m2. Graph is drawn between no. of blows (log scale) and water content (natural scale). Water content corresponding to 25 no of blows is taken as 'liquid limit (WL) .Liquidity index - The liquidity index (IL) is a ratio of difference between natural water content, plastic limit, and liquid limit. LI=(W-Wp)/(WL-Wp) where, W is the natural water content.

b) Plastic limit (Wp) - Plastic limit of soil sample is defined a water content at which soil sample change from semisolid to plastic state. It is also defined as the water content at which soil would just begin to crumble into thread of approximately 3mm diameter.

c) Plasticity Index (Ip) - plasticity index is defined as the difference between the liquid limit and plastic limit of soil. Ip= WL- Wp

2) Specific gravity (G) - Specific gravity of soil solids defined as the ratio of weight of a given volume of soil solids at a certain temperature to the weight of an equal volume of standard liquid usually distilled water at the same temperature, both weights being taken in air. It is denoted by the letter 'G'. Normally 'G' is reported at 27^{oC}. We can determine the specific gravity of soil solids by using Pycnometer method.

3) CBR test- C.B.R testing is a method of evaluating the relative quality of sub grade, sub base and soil for pavement. California Bearing Ratio is the ratio of the force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm per minute to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 mm and 5 mm.

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Penetration depth (mm)	Unit standard load (kg/sqcm)	Total standard load (kg)
2.5	70	1370
5	105	2055
7.5	134	2630
10	162	3180
12.5	183	3600

4) Standard proctor test - The Proctor compaction test is a laboratory method of experimentally determining the optimum moisture content at which a given soil type will become most dense and achieve its maximum dry density.Plotting is done between dry density and moisture content on the enclosed graph and from the graph value of maximum dry density and the optimum moisture content are to be determined.

rd = r / 1+w

where, rd- dry density

r - bulk density

W-Water content.

5) UCS (unconfined compressive test) - Unconfined compressive strength (qu) is the load per unit area at which an unconfined cylindrical specimen of soil will fail in simple compression test.

Sensitivity: Sensitivity is defined as the ratio of U.S.C. of undisturbed soil sample to the U.S.C. of remoulded sample of constant moisture contained.

IV. LITERATURE REVIEW

1) Shubham More, ApekshaLokhande, Shaikh Sabir, Pooja Aade, NilambarikaBansode, Omkar Joshi "Stabilization of Black Cotton Soil by Using Steel Slag" International Journal of Innovative Research in Science, Engineering and Technology High Impact Factor, Monthly, Peer Reviewed Journal, Vol. 7, Issue 5, May 2018.

In this paper author can discuss about the disposal problem of industrial waste is rapidly increasing. Such, hazardous waste is affecting the environment as well as land. To protect the land and environment from industrial waste author can utilized that waste for the construction purpose.steel slag used for stabilizing the black cotton soil and for minimizing the waste. The use of steel slag improves the bearing capacity and the strength of black cotton soil and indirectly it saves the construction cost. Different percentage of 5%, 10%, 15% and 20% of steel slag have been used to stabilize the black cotton soil and to verify its suitability for using it as a construction material for road. The steel slag collected from Kalika Steel, Jalna and the black cotton soil collected form Himayatbaugh, Aurangabad. Rebecca Belay Kassa, Tenaw Workie, AlyuAbdela, MikiyasFekade, Mubarek Saleh, Yonas Dejene,"Soil Stabilization Using Waste Plastic Materials", Open Journal of Civil Engineering, 2020. In this research paper author can discuss about the Expansive clay soils have a behaviour of swelling and shrinking, that is a serious hazard to structures built over them. This paper shows the outcomes of an attempt to reinforce and stabilize expansive clay soil with plastic bottle strips. The plastic strips were prepared and added at three different mixing ratios (0.5%, 1% and 2%) by weight and in three different aspect ratios (5 mm × 7.5 mm, 10 mm × 15 mm, 15 mm × 20 mm). Stabilizing expansive clay soils with waste plastic bottles simultaneously solves the challenges of improper plastic waste recycling that is currently a teething problem in most developing countries. The results obtained from this study favourably suggest that inclusion of this material in expansive soils would be effective for ground improvement in geotechnical engineering.

2) Tushar PundlikraoThombre, Dr. Shubhada S. Koranne," Stabilization of Black Cotton Soil by Using Steel Slag Powder" International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 09, Sep 2018.In this paper author can mention that how to improve the engineering properties of expansive soil using steel slag powder and utilization of industrial waste'. for that purpose, samples were prepared by mixing the percentage of steel slag powder and expansive soil as 5%, 10%, 15%, 20%, 25% and 30% by the dry weight.

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The various experimental test results indicate significant increase in strength at 30% steel slag powder content. Standard proctor test, unconfined compressive strength, liquid limit and plastic limit tests are performed to analysis compressive strength, Maximum dry density (MDD) and optimum moisture content (OMC) of soil mixture.

3) Ujwalakamble, Prof. V.Y. Deshmukh, Pritam Thak, JagrutiTher, JavedShaha, "Soil Stabilization By Using Plastic Waste "International Journal of Aquatic Science ISSN: 2008-8019 Vol 13, Issue 01, 2022 .

Day by day use of plastic products such as polythene bags, bottles etc. is increasing leading to various environmental concerns. Therefore, the disposal of the plastic wastes without causing any ecological hazards has become a real challenge. Thus, using plastic bottles as a soil stabilizer is an economical utilization, since there is scarcity of good quality soil for embankments. This project involves the detailed study on the possible use of waste plastic bottles for soil stabilization.

4) Nitesh, Sumesh Jain," Soil Stabilization Study by using Steel Slag",International Journal of Trend in Scientific Research and Development, (IJTSRD) (Online)2456 – 6470, Volume 3, Issue 5, August 2019.

According to author by utilizing the common waste materials for the improvement of roads. One such material that was analyzed in the paper for the execution of road work is the steel slag. The use of the material is found to have improved the sub grade properties of soil to a good extent.

5) Hussein Jalal Aswad Hassan &Jabar Rasul &MaleahaSamin,"Effects of Plastic Waste Materials on GeotechnicalProperties of Clayey Soil"

Recently, the use of plastic products, has been significantly increased, which may lead to many environmentalissues. Therefore, it is important to find methods to manage these waste materialswithout causing any ecological hazards. One of these methods is to use plastic wastesas soil stabilizer materials. The effect of the stabilization was evaluated through carrying out standard laboratorytests. These tests have been conducted on natural and stabilized soils with four fibercontents (1%, 2%, 3%, and 4%) of the soil weight. The tests included the standardcompaction test, UCS test, CBR test, and resilient modulus (Mr.) tests. In all these tests, the fiber content wasadded in two lengths, which were 1.0 cm and 2.0 cm. Laboratory test results revealedthat the plastic pieces decrease maximum dry density (MDD) and optimum moisturecontent (OMC) of the stabilized soils.

V. RESULTS AND DISCUSSION

SR. NO.	Engineering Property	Black Cotton soil	Stabilized black cotton soil	Remark with respect to black cotton soil
1	Atterberg limit			
a	Liquid limit (%)	71	45.8	25.2% decrease
b	Plastic limit (%)	23	15.2	7.8% decrease
c	Plasticity index (%)	48	30.6	17.4% decrease
2	Specific gravity	2.72	3.159	0.439 increase
3	CBR (%)	4	8.1	4.1% increase
4	Standard Procter test			
4.1	OMC (%)	24	18	6% decrease
4.2	Maximum dry unit Weight (g/cc)	1.71	1.92	0.21g/cc increase
5	UCS (KPa)	89	272.5	183.5 KPa increase

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VI. CONCLUSION

In this research paper, we can stabilize black cotton soil by adding steel slag and plastic bottle strips. Steel slag and plastic which are major hazards to the environment, to avoid such type of impact on the environment, we can use as a admixture for soil stabilization. It is also economical soil stabilizer as compared to another type of soil stabilizer. From the above study, due to the addition of such type of waste material (i.e., 25% steel slag and 5% plastic bottle strip). It can increase the bearing capacity and stability of black cotton soil and reduce optimum moisture content. Whereas the unconfined compressive strength is increases and dry density is also increases.

VII. REFERENCES

[1] Bhanu Prakash Darsi, "Subgrade Black Cotton Soil Stabilization Using Ground Granulated Blast-Furnace Slag (GGBS) and Lime, an Inorganic Mineral"

[2] Chippada Srinivas, "Experimental Investigation on Expansive Soil Stabilization by Using Steel Slag" International Journal of Mechanics and Solids, Volume 12, Number 1 (2017).

[3] Hussein Jalal Aswad Hassan &Jabar Rasul &MaleahaSamin,"Effects of Plastic Waste Materials on GeotechnicalProperties of Clayey Soil"

[4] K. H. Mamatha and V. S. Dinesh, "Resilient Modulus of Black Cotton Soil", 28 Jan 2017

[5] Nitesh, Sumesh Jain," Soil Stabilization Study by using Steel Slag", International Journal of Trend in Scientific Research and Development, (IJTSRD) (Online)2456 – 6470, Volume 3, Issue 5, August 2019.

[6] Rebecca Belay Kassa, Tenaw Workie, AlyuAbdela, MikiyasFekade, Mubarek Saleh, Yonas Dejene,"Soil Stabilization Using Waste Plastic Materials",Open Journal of Civil Engineering, 2020.

[7] Shubham More, ApekshaLokhande, Shaikh Sabir, Pooja Aade, NilambarikaBansode, Omkar Joshi "Stabilization of Black Cotton Soil by Using Steel Slag"International Journal of Innovative Research in Science, Engineering and Technology High Impact Factor, Monthly, Peer Reviewed Journal, Vol. 7, Issue 5, May 2018.

[8] Tushar PundlikraoThombre, Dr. Shubhada S. Koranne," Stabilization of Black Cotton Soil by Using Steel Slag Powder" International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 09, Sep 2018.

[9] Ujwalakamble, Prof. V.Y. Deshmukh, Pritam Thak, JagrutiTher, JavedShaha, "Soil Stabilization By Using Plastic Waste"International Journal of Aquatic Science ISSN: 2008-8019 Vol 13, Issue 01, 2022.

[10] https://www.vedantu.com/chemistry/disadvantages-of-plastics.

[11] https://civiconcepts.com/blog/black-cotton-soil.

[12] https://www.slg.jp/e/slag/product/doboku.html.