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Stabilization of Black Cotton Soil Using Red Mud and Hydrated Lime

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ABSTRACT- This research paper is an effort to use those materials which are disposed as wastes for stabilizing the soil and making the process cost effective. In this research work, two waste materials such as Red Mud and Hydrated Lime is used in different percentages. Hydrated lime (HL) is blended with the natural sample of soil in the proportion of (0%, 2%, 4%, 6%, 8%, and 10%) by weight of soil. 6% Hydrated lime was taken as an optimum proportion depending on UCS values. The UCS value of natural soil showed an increment from 89.5KN/m2 to 120.6 KN/m2 when 6% HL was blended with the natural soil. This value showed further an increment when the Soil+6% HL mix was cured. The UCS value raised to 192.3 KN/m2and 242.23 KN/m2 when cured for a period of 7 and 28 days respectively. Then RM was added in different proportion (5%, 10%, 15% and 20%) to Soil+ 6% HL mix. It was revealed from results that the UCS attained a maximum value of 235.6 KN/m2 at the addition of 6% HL and 15% RM to the natural soil. This value further showed an improvement to 279.4KN/m2, 307.4KN/m2 and 316.7 KN/m2 when the sample was cured for 7 and 28 days respectively.

KEYWORDS- Black cotton soil (BCS), Hydrated lime (HL), Red mud (RM)., maximum dry density (MDD) shrinkage,

I. INTRODUCTION

A. General

Now a day, the population of the world is increasing in alarming rate and India is the second largest populated country of the world after China, which results unavailability of good land for constructed purpose[1]. Population of Mumbai in 1981-91 enhanced from 8.2 million to 12.3 million. During the same time, municipal solid wastes has increased from 3200 tonnes to 5355 tonnes, which means an increment of 67% [2]. Total generation of waste per day is 1 lakh. Thus unavailability of land for any Engineering projects needs to be built on weak and unsafe soil which became main reason for many unsuccessful engineering works. With the result to it soil stabilization emerges as one of the successful engineering technique to enhance qualities of unsound and unsafe soil for construction purpose. Soil stabilization is a process that changes and improves the engineering features of soil to make it more suitable for construction [3]. It is a technique to improve and increase the physical, mechanical and chemical (by adding chemical admixture to soil) qualities of the soil as soil is one of the basic or crucial construction raw material [4]. As such, soil should possess the properties that make the soil suitable for concrete foundation [5]. But all the soil sites didn't have favourable construction conditions. At such sites, an engineer mostly has four main options at his disposal and they are:

- Moving to a new construction site
- Replacing poor grade soils with soil possessing rich grade topsoil.
- Changing the proposed structure to suit the poor grade properties of the soil.
- Finally, improving the properties of the soil on site.

Today, with better research and more effective materials and technology, soil stabilization is considered the most feasible options for all construction purposes [6]. The benefits of soil stabilization are long lasting as well as cost effective which includes strength improvement such as shearing and compressive strength, controlling shrinkage, improving bearing capacity, reducing plasticity index(PI), reducing permeability, reducing deformation, improving durability, water proofing etc. Black cotton soils or black clays or tropical black earth are major problematic soils especially in Africa and India. Black cotton soils have been found all over the world and have been noticed to comprise about 2% of the total ice free land area of the earth and in India it is in very large quantity (72 million hectares) [7]. Geographically, black soils unfurl over 5.46 lakh sq.km i.e 16. Total land covered by black cotton soil in India is 6%. These soils are mostly established in Central India and a part of South India. Black soil is extremely developed in part of Maharashtra, Gujarat, North Highest percentage of black soil is in Maharashtra (27%) followed by Madhya Pradesh (21.3%), Gujarat (11.5%), Karnataka (9.2%), Andhra Pradesh (7.1%) and Chhattisgarh (5.6%). These soils have a high water-holding capacity, a high swelling capacity due to monsoon water absorption, and a high shrinkage capacity due to summer water evaporation . The constructions built on these soils incur fissures as a result of their growing and shrinking qualities, rendering them unsuitable for foundation. Hence, there is requirement for improving of black cotton soil properties to suit as foundation material. Dark cotton soil which is one of the significant soil stores in western parts of Andhra Pradesh, Western parts of Madhya Pradesh, Tamil Nadu, Rajasthan,

Karnataka, Chhattisgarh, Jharkhand up to Raj Mahal hills. The Malwa plateau and the Deccan plateau also lie in the extend of black soil. India turns out to be profoundly dangerous on account of its property of more serious level of expanding and shrinkage. These solid wastes are utilized in subgrade of asphalt and furthermore in development of constructions. As a result, a variety of strategies such as soil adjustment, soil replacement, moisture control, pre wetting and others are available to improve the qualities of such soils. Soil aeration with various minerals such as quarry dust, saw dust, copper residue and fly debris has become increasingly popular in recent years. These powerful wastes are steadily developing in India, which isn't natural friendly. Consequently, an audit is introduced to utilize those losses in soil adjustment. In this, the examination predominantly focusses on adjustment of stabilized soil using solid waste. To comprehend the presentation of balanced out soil, its properties like Atterberg limits, compaction attributes, expanding, shear strength, CBR esteem and other Index and Engineering properties were talked about.

II. LITERATURE REVIEW

A. Red Mud and Hydrated Lime

- Samuel Tadese and Meron Wubshet (2014) This research is centred on the use of bagasse ash and lime to stabilise black cotton soil. 3 percent lime, 15% bagasse ash, and 15% bagasse combined with 3 percent lime by dry weight of the soil are utilised in this. The effect of additives on soil was studied using a variety of experiments, including plasticity, compaction, and the California bearing ratio test. With the addition of lime or bagasse ash, the plasticity index was found to be greatly reduced. It was also discovered that mixing bagasse ash alone has just a minor impact on the plasticity index. With the addition of lime, bagasse ash, and bagasse ash coupled with lime, the maximum dry density (MDD) of stabilised soil drops. The mixture of bagasse ash and lime can significantly improve the expansive soil strength. This research also demonstrates that mixing two locally available elements can improve the qualities of expansive soil significantly [8].
- Nadgouda, K.A. and Hegde, R. A. (2010): This study shows the effective behaviour in the properties of black cotton soil by stabilizing it with lime. Percentage of lime content used varying from 2.5% to 7.5%. optimum lime content was identified between 3.5% to 4.5%. As the lime content increase, plasticity index decrease but stiffness increase as we increase the lime content. Here, we get to know that lime as a stabilizer improves various properties of black cotton soil [9].
- Kumar and Agarwal (2019): Here different percentages of red mud 10%, 15% and 20% are mixed with 0.2%, 0.3% and 0.5% polythene strip in the black cotton soil. In this study, by adding 20% red mud with 0.3% 0f polythene strip in the soil, maximum value of unconfined compression strength is attained as 0.97kg/cm2. Addition of soil sample with 20% red mud and 0.2% polythene strip, 6.22% optimum CBR value was obtained. This study also shows that after increasing percentage of red mud in the soil, liquid limit and plastic limit shows decrement but as we adding 0.5% polythene strip in it, its value again shows increment [10]
- Nitin Mane and Prof. M. S. Rajashekhar (2017): Here red mud and sodium silicate were used with black cotton soil for its stabilization. Proportion of red mud used were 10% to 40% with 10% increment. Proportion 0f sodium silicate used were 2% to 105 with 2% increment. Tests performed were unconfined compression strength test and California bearing ratio test. 0.587kg/sq.cm were attained as maximum value of UCS by the addition of 30% red mud along with 2% sodium silicate in the soil. 0.889kg/sq.cm were observed as maximum value of unconfined compression strength at 20% red mud and 4% sodium silicate. Addition of 30% red mud and 6% sodium silicate shows 1.314kg/sq.cm maximum value of unconfined compression strength. Further, addition of 30% red mud and 6% sodium silicate shows 0.88kg/sq.cm maximum value of UCS. Adding 30% RM and 10% sodium silicate, the maximum value of UCS was obtained as 0.621 kg/sq.cm. Thus, by the combination of 30% RM and 6% sodium silicate, optimum value of UCS attained was 1.314kg/sq.cm. Similarly, ultimate value of CBR was attained at 30% RM and 8% sodium silicate [11].
- Shailendra Singh (2015): Lime content were added with BCS to study the effective behaviour of various engineering properties. Proportion of lime content used here were 0%, 4% and 6% in the soil. Liquid limit shows 12.1% reduction upon using 4% lime in the soil and 17.7% reduction upon using 6% lime. Reduction of 2.4% and 5.6% in maximum dry density was obtained at 4% and 6% lime content. At 6% lime content, 14.3% reduction in OMC was observed. By adding 4% and 6% lime content in the black cotton soil swelling pressure shows reduction of 40% and 80% respectively[12].
- I.N. Obeta et.al (2019): Saw dust and lime are added with black cotton soil. Varying percentages of 4%, 8%, 12%, 16% and 20% are mixed with black cotton soil. Better results are attained by 16% saw dust. Further, 16% saw dust was added with lime stabilizer ratio of 2%, 4%, 8% and 10%. By using 4% lime stabilizer with 16% saw dust in the soil, maximum increase in CBR and specific gravity was achieved and maximum reduction in liquid limit, differential free swell and atterberg limits were attained. Thus, best results were achieved with 16% saw dust ash and 4% lime [13].

III. SELECTION OF MATERIALS AND METHODOLOGY

A. Black cotton soil

Black soil gets its name from the occurrence of titaniferous magnetite, which gives it a dark colour. It is rich in the clay rich soil i.e it is rich in calcium, iron, potassium and hold moisture. It can be found throughout the tropics and sub tropics. It contains a low amount of nitrogen, phosphorous and organic matter. So, it is more fertile on low lands than uplands. Black soil forms the cracks during the dry season due to high porosity. Though it is very good soil for cultivation but is challenging work for civil engineering work due to its swelling and shrinkage property. Black Cotton Soils cover a vast portion of central and southern

India, including Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, South Gujarat, and Uttar Pradesh. Approximately 3,00,000 square kilometres are covered.

B. Red Mud

The red mud used in this experiment was brought from MANIDHARMA BIOTECH PRIVATE LIMITED MOULIVAKKAM CHENNAI, INDIA. Red mud is also known as bauxite residue as it is generated from industrial waste through Bayer process (processing of bauxite into alumina). It id red in colour because of the presence of iron oxide. It is a solid waste generated from aluminium industry. Panic over addressing the red mud disposal has gained ground especially after a report said country has piled upon an inventory of 200 million tonnes of the residue. Because of its high alkalinity and species composition, red mud discharge can be detrimental to the environment.

C. Hydrated Lime

Lime has many classifications and on the basis of calcination of limestone, hydrate lime is one among them. In this study, hydrated lime used is brought from the local market and is easily available. It can be used as a construction material. It is also famous as water lime as it sets under water and in the absence of carbon dioxide it becomes hard. One of those materials which can be used in large civil engineering works. Contains 30% of clay and is similar to cement to some extent. Slaked lime is another name for it. It is water soluble. It has no odour. It's either white or colourless crystal [14]. It comes in the shape of a powder. When calcium oxide is combined with lime, hydrated lime is created.

IV. TEST METHODS

- Specific gravity
- Atterberg`s limit
- Proctor compaction test
- Unconfined compression strength test

A. Results

From this study, while performing the experimental investigations on black cotton soil with varying % of RM and at an optimum mix of HL, it was shown that properties of soil improved to some extent. The effective changes shown by soil are as follows:

- The MDD decreases from 1.962 g/cc to 1.616 g/cc while performing proctor compaction test with varying % of HL and 20% OMC .Fig. 1 shows Variation of MDD with different mixes in soi
- At 2% HL, MDD decreases from 1.834g/cc to 1.697g/cc.
- At 4% HL, MDD decreases from 1.697g/cc to 1.616g/cc and at 8% HL, MDD decreases from 1.616g/cc to 1.510g/cc and 20% OMC.
- At 10% HL, the MDD decreases from 1.510g/cc to 1.454g/cc at 24% OMC.
- Thus, 6% HL is obtained as optimum % of HL in proctor compaction test. The MDD decreases from 1.962 g/cc to 1.616 g/cc while performing proctor compaction test with varying % of HL and 20% OMC.
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- At 10% HL, the MDD decreases from 1.510g/cc to 1.454g/cc at 24% OMC.
- Thus, 6% HL is obtained as optimum % of HL in proctor compaction test.
- The specific gravity of black cotton soil is 2.61 and the specific gravity of HL and RM are 2 and 3.3 respectively. The MDD decreases from 1.962 g/cc to 1.616 g/cc while performing proctor compaction test with varying % of HL and 20% OMC.
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- At 10% HL, the MDD decreases from 1.510g/cc to 1.454g/cc at 24% OMC.
- Thus, 6% HL is obtained as optimum % of HL in proctor compaction test.
- The specific gravity of black cotton soil is 2.61 and the specific gravity of HL and RM are 2 and 3.3 respectively. By mixing BCS with 6% HL and varying percentages of red mud, the specific gravity increases which is because red mud has high density and strength. It can be seen that maximum dry density of red mud is also better and is best to use it as a subgrade.Fig. 2 shows Variation of MDD of BCS with optimum mix of 0, 7 and 28 days of curing age
- By performing proctor compaction test with BCS+6% HL mix and varying % of RM, the MDD obtained 1.70g/cc till 15% RM. Beyond 15% the maximum dry density shows decrement. Thus, we get to know that MDD was achieved at 15% RM at 18% 0MC. Here, 15% is optimum % of red mud.
- The UCS of soil when mixed with hydrated lime obtained was 120.6Kpa, 170.6Kpa and 240.32Kpa at 0, 7 and 28 curing days. The maximum compressive strength was achieved at 6% HL. So, 6% is optimum % of HL in UCS test that means soil shows maximum compressive strength at this percentage.
- While performing UCS test with BCS+6% HL mix and varying % of RM, compressive strength obtained was 235.6Kpa, 279.4Kpa and 316.7Kpa at 0, 7 and 28 curing age. At 15% RM, maximum compressive strength was achieved and 15% is taken as optimum % of red mud. Fig. 3 Shows Variation of OMC of BCS at optimum mix.

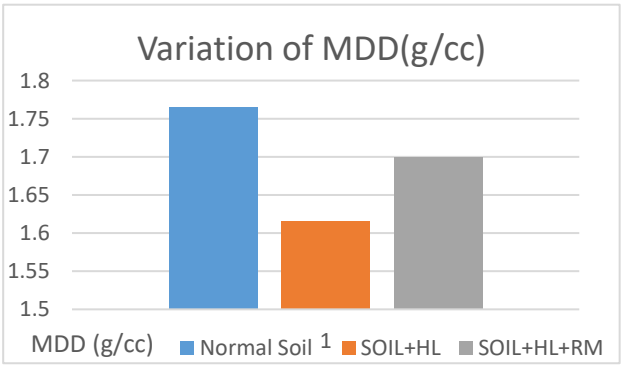

Figure 1: Variation of MDD with different mixes in soil

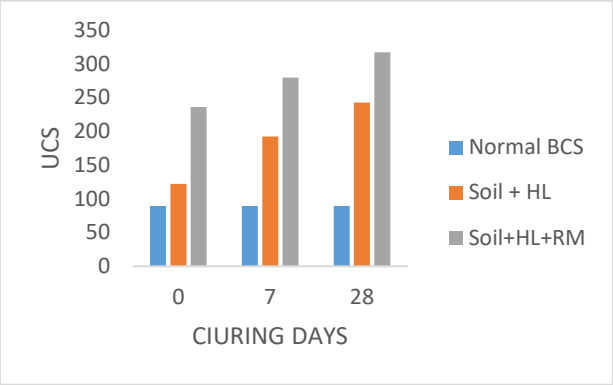

Figure 2: Variation of MDD of BCS with optimum mix of 0, 7 and 28 days of curing age

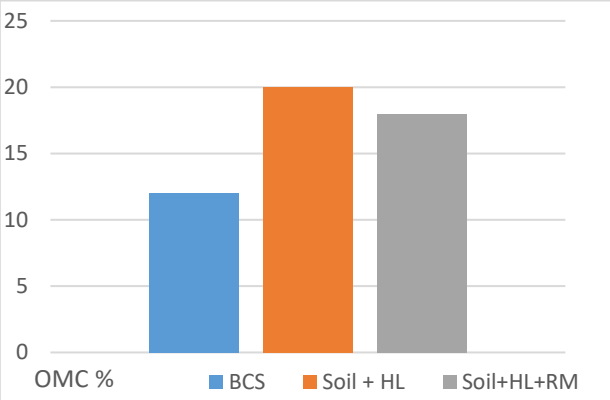

Figure 3: Variation of OMC of BCS at optimum mix

VI. CONCLUSION

- From all these investigations and results achieved, we get to know that 6% HL and 15% RM gives best results when added in black cotton soil. Red mud can be used as an embankment because of its low absorbent property.
- Thus, red mud can be used in stabilization of black cotton soil along with hydrated lime instead of being disposed on land as a waste material that cause many serious environment problems.

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