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Impact of Addition of Stabilizers on the Properties of Black Cotton Soil

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ABSTRACT

Everyday a huge quantity of waste is generated. With growing population and development waste disposal has become a problem, so here use of these waste for enhancing the soil properties is studied. For this purpose the wastes selected are Waste marble powder (WMP) and Ground Granulated Blast Furnace Slag (GGBFS) and their effects on the soil characteristics is monitored.

Keywords : Waste Marble Powder, Ground Granulated Blast Furnace Slag, CBR, UCS

I. INTRODUCTION

For construction purposes on the in situ soil, the basic necessity is that the soil must have high strength characteristics. If the locally available soil does not have high strength then options available are:-

1. Modify the design.
2. Replace the locally available soil.
3. Avoid the site for construction purpose.

All these above mentioned options are time consuming, highly expensive and sometimes not feasible according to the situations prevailing. The soil is said not to be feasible for various engineering practices if accordingly it has low bearing capacity, soil has low CBR value, soil is prone to liquification, has high swelling and shrinkage characteristics, has low UCS value etc. Also due to ever increasing population there is scarcity of land and also some sites are prone to landslides. So, now locally available soil has to be modified with some operations on it so that its strength increases up to a desirable limit and now further construction can be done. These operations which are done on the locally available soil to make it fit for the construction is called soil stabilization.

1.1 Soil Stabilization

Any method which is done on the locally available soil to improve its engineering properties and strength is called soil stabilisation. Improvement can be done physically, chemically, biologcally, mechanically etc. This all can be done by compaction, reinforcement with fibres, introducing sand drains, addition of chemicals etc. Also, one of the problem arising nowdays is of waste disposal. Engineers have to deal with this problem of waste disposal and one of the solution available is to use these wastes for the stabilisation of soil. This benefits as:-

1. Cost is reduced by using waste material as soil stabilizer.
2. Problem of waste disposal is solved and is eco friendly.

Wastes which can be used as a soil stabilizer are rice husk, wheat husk, coirs, fibres, banana leaves, blast furnace slag, stone dust etc. The only thing is these wastes must be eco-friendly and economical viable. Keeping this in mind we have studied use of marble powder and terrazyme as wastes for soil stabilization. The success of such soil stabilization depends on the testing. The methods employed to stabilize the soil, should be verified in the lab with the soil material before applying it on the field

II. Literature Review

Abdul Waheed et. Al. [1] works on the Soil Improvement Using Waste Marble Dust for Sustainable Development. The soils which show very high shear strength in a dry state but rapidly lose their strength on wetting are known as collapsible soils. Such rapid and massive loss of strength produces severe distress leading to extensive cracking and differential settlements, instability of building foundations, and even collapse of structures built on these soils. Waste marble dust is an industrial byproduct and is being produced in large quantities globally poses an environmental hazard. Therefore, it is of the utmost need to look for some sustainable solution for its disposal. The present study focused on the mitigation of the collapse potential of CL-ML soil through a physio-chemical process. The soil is sensitive to wetting, warranting its stabilization. Waste marble dust (WMD) in varying percentages was used as an admixture. The study's optimization process showed that geotechnical parameters of collapsible soil improved substantially by adding waste marble dust. Plasticity was reduced while Unconfined Compressive Strength (UCS) significantly increased while swelling was reduced to an acceptable limit. The California Bearing Ratio (CBR) also exhibits considerable improvement. This study appraises the safe disposal of hazardous waste safely and turns these into suitable material for engineering purposes.

Tozsin, G. et. Al [2] studied on Using marble wastes as a soil amendment for acidic soil neutralization. One of the most important factors limiting plant growth is soil pH. The objective of this study is to determine the effectiveness of marble waste applications on neutralization of soil acidity. Marble quarry waste (MQW) and marble cutting waste (MCW) were applied to an acid soil at different rates and their effectiveness on neutralization was evaluated by a laboratory incubation test. The results showed that soil pH increased from 4.71 to 6.36 and 6.84 by applications of MCW and MQW, respectively. It was suggested that MQW and MCW could be used as soil amendments for the neutralization of acid soils and thus the negative impact of marble wastes on the environment could be reduced.

Sabat, A.K. and Nanda [3] studied the Effect of marble dust on strength and durability of Rice husk ash stabilised expansive soil. It presents the results of a laboratory study undertaken to investigate the effect of Marble dusts on strength and durability of an expansive soil stabilized with optimum percentage of Rice Husk ash (RHA). The optimum percentage of RHA was found out be 10% based on

Unconfined Compressive Strength (UCS) tests. Marble dust was added to RHA stabilized expansive soil up to 30%, by dry weight of the soil, at an increment of 5%. Compaction tests, UCS tests, Soaked California Bearing Ratio (CBR) tests, Swelling pressure tests and Durability tests were conducted on these samples after 7 days of curing. The UCS, and Soaked CBR of RHAstabilized expansive soil increased up to 20% addition of Marble dust. Further addition of Marble dust had negative effects on these properties. The Maximum Dry

Density(MDD) and Swelling pressure of expansive soil goes on decreasing and Optimum Moisture Content (OMC) goes on increasing irrespective of the percentage of addition of Marble dust to RHA stabilized expansive soil. From the Durability test results it was found that the addition of Marble dust had made the RHA stabilized expansive soil durable. For best stabilization effect the optimum proportion of Soil: Rice husk ash: Marble dust was found to be 70: 10: 20.

Yilmaz, F. and Yurdakul, [4] works on the Evaluation of Marble Dust for Soil Stabilization. It Usage of marble dust was investigated for soil stabilization in the scope of utilization of waste material. Geotechnical properties, such as compaction, Atterberg limits, unconfined compressive strength of the mixtures and changes of these properties with the marble dust ratio were determined. From the test results it is seen that marble dust increases the mechanical properties of soil and application of dust wastes for soil stabilization will be an efficient practice in terms of solid waste management.

PriyankaShaka et al (2016) [5] Based on IS classification, red soil is classified as Clayey sand and the black cotton soil as highly compressible clay. Laboratory testing showed that decrease in liquid limit and plasticity index was observed with the increase in dosages of Terrazyme. Also, the Terrazyme dosage of 200ml/0.75m3 of dry soil garnered the best result. Further increase in the dosage does not alter the plasticity characteristics of soils substantially. CBR Value of the soil sample was increased by 2.75%. 3.345%. 3.47% and 3.56% by application of the bio-enzyme with a dosage of 200ml/0.75m3. With further increase in the dosage of the enzyme, no substantial increase was recorded.

Lacuoture and Gonzalez (1995) [6] conducted a comprehensive study of the TerraZyme soil stabilizer product and its effectiveness on sub-base and sub-grade soils. The reactions of the soils treated with the enzyme was observed and recorded and compared to the untreated control samples. The variation in properties was observed over a short period only and it was found that in cohesive soils there was no major variation in properties during the early days but the soil showed improved performance progressively.

Isaac et al (2003) [7] studied effectiveness of Terrazyme on lateritic and clay type soil collected from Kerala. The reactions of the soils treated with enzyme were recoded for 8 weeks. The CBR value increased in all soil type in the range of 136 to 1800 percent that of the original value by addition of Terrazyme, which proved its suitability as a stabilizing agent. Terrazyme is useful for clay soil and sand but is less significant to silty soils; clayey and sandy soils had increase in CBR by 700 percent.

Swathy M Muraleedharan1, Niranjana (2015) [8] conducted laboratory tests on clay of high plasticity treated with Terrazyme. The effect of enzyme on soil in terms of Plasticity Index, Compaction, Unconfined Compressive Strength (UCC), and California Bearing Ratio (CBR) were studied. The dosage of bio-enzyme added to the soil was 0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml per kg soil on bio stabilized soil .The soil properties showed improvement in stabilizing with enzyme dosage of 0.2ml/kg. The treated soil was observed to be having lesser plasticity index values. For the optimum dosage, the MDD of the up to 6% and OMC decreases up to 19%. At the optimum dosage, there was an increase of 351%in the UCC strength and 352% in CBR value of soil.

Sharma, A.K. and Sivapullaiah, P.V. [9] works on Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer. The potential of using a binder for stabilization of expansive soils that consists of a mixture of fly ash and ground granulated blast furnace slag (GGBS) is evaluated in this study. The joint use of these two materials to form a binder provides new opportunities to enhance pozzolanic activities that may reduce the swell potential and increase the unconfined compressive strength of expansive clays. The influence of different percentages of binder on the Atterberg limits, compaction characteristics and unconfined compressive strength of an artificially-mixed soil were examined. The addition of binder was shown to bring about a significant improvement in these soil properties. It was found that the liquid limit and plasticity index of the expansive soil decreased considerably with the addition of binder, while the strength improved. Adding a small amount of lime (one percent) further improved the soil properties by enhancing the pozzolanic reactivity of the binder. Based on the results of the unconfined compressive strength tests, the addition of 20% binder is recommended as optimum content. In addition, the mineralogical and morphological studies of soil specimen stabilized with optimum binder content suggested the formation of hydrated particles and cementitious compounds as a result of the reaction between the clay and the binder. Test results indicate that the use of GGBS mixed fly ash as binder to stabilize expansive is well suited for sustainable construction besides economic benefits.

Pathak, A.K. et al [10] studied the Soil stabilisation using ground granulated blast furnace slag. Stabilisation is a broad sense for the various methods employed and modifying the properties of a soil to improve its engineering performance and used for a variety of engineering works. In today‟s day soil stabilisation is the major problem for civil engineers, either for construction of road and also for increasing the strength or stability of soil and reduces the construction cost. In this work the soil are stabilised by ground granulated blast furnace slag (GGBS) and this material is obtained from the blast furnace of cement plant, which is the byproduct of iron (from ACC plant, sindri). It is generally obtained in three shaped one is air cooled, foamed shaped and another is in granulated shaped. The use of byproduct materials for stabilisation has environmental and economic benefits. Ground granulated blast furnace slag (GGBS) material is used in the current work to stabilise soil (clay). The main objectives of this research were to investigate the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilised. Granulated shaped blast furnace slag is most suitable for increasing the strength of the soil and for this we check the following property of soil. GGBS are added from 0% to 25% by dry weight of soil, first of all check the all soil property at 0 % (no GGBS) and then compare after addition of GGBS from 5% to 25%. The investigations showed that generally the engineering properties which improved with the addition of GGBS. The addition of GGBS resulted in a dramatic improvement within the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with increasing GGBS content and at 25% we got the maximum value of dry density.

Thomas, A. et al [11] works in a Laboratory Investigation of Soil Stabilization Using Enzyme and Alkali-Activated Ground Granulated Blast-Furnace Slag. Development and use of non-traditional stabilizers such as enzyme and alkali-activated ground granulated blast-furnace slag (GGBS) for soil stabilization helps to reduce the cost and the detrimental effects on the environment. The objective of this study is to investigate the effectiveness of alkali-activated GGBS and enzyme as compared to ordinary Portland cement (OPC) on the soil collected from Tilda region of Chhattisgarh, India. Geopolymers are alkali alumino-silicates produced when combining a solid alumina-silicate with an aqueous alkali hydroxide or silicate solution. Various dosages of the selected stabilizers have been used and evaluated for the effects on optimum moisture content (OMC), maximum dry density, plasticity index, unconfined compressive strength (UCS) and shear strength parameters. Effect of curing period has also been studied. Microstructural changes of the stabilized soils show aggregation of particles. Significant improvement in properties of soil is observed with the addition of stabilizers leading to an increase in OMC, UCS and shear strength parameters. It is observed that the cohesion of soil sample increases significantly with the addition of stabilizers whereas there is a marginal change in angle of internal friction. Thus, the findings recommend the use of non-conventional stabilizer such as alkali-activated GGBS and enzyme as suitable and environmental friendly as compared to OPC for soil stabilization.

Mujtaba, H. [12] studied the Improvement in Engineering Properties of Expansive Soils using Ground Granulated Blast Furnace Slag. Improvement in engineering properties of expansive soils by mixing ground granulated blast furnace slag (GGBFS) is the main focus of this research. For this purpose two expansive soil samples were collected from DG Khan and Sialkot areas (Pakistan). Classification tests revealed that DG Khan sample belonged to fat clay (CH) while Sialkot soil was lean clay (CL) as classified by Unified Soil Classification System. GGBFS has been added in varying proportions between 0 and 55% in these soil samples to study its role in stabilizing these expansive soils. Based on the laboratory test performed on composite soil samples, it was observed that maximum dry unit weight increased up to 10 % by adding 50% GGBFS in both samples. California bearing ratio (CBR) value showed an increase from 3.2 % to 11.5% for DG Khan soil while CBR values varied from 2.4% to 10.7% for Sialkot soil by mixing 50% GGBFS. Addition of 30 % GGBFS to DG Khan soil reduced swell potential from 8 % to 2 % while in Sialkot soil, 20 % addition of GGBFS reduced swell potential from 5 % to 2 %. Unconfined compressive strength of remoulded sample cured for 28 days increased by about 35% with the addition of 30%GGBFS. The results indicated that mixing of GGBFS in the expansive soil samples have a marked increase in their engineering properties. Also, it is an affective and environmental friendly means to dispose waste of steel industry.

Research by Simatupang et al. [13] investigated the stability of soil with the addition of fly ash. Fly ash percentages range from 5–25% by dry weight of soil. By increasing the fly ash content in the samples and the curing time, the compressive strength value for fly ash increased. However, a long curing time is required to reach the optimum strength. To shorten the curing period, adding other materials such as GGBFS may be necessary.

Another study in 2016 by Dayalan et al. [14] investigated soil stabilization with ground granulated blast furnace slag (GGBFS). Different percentages of GGBFS 5–25% by dry weight of soil were used to stabilize the clayey soil. Based on the strength performance test, the optimum amount of GGBFS was determined to be 20%. Moreover, the result indicates that the inclusion of GGBFS increases the strength of clayey soils but the acquired properties do not meet the ASTM D 4609 soil-stabilizing criteria for road construction applications.

Another study in the same year by Mandal et al. [15] investigated soil stabilization using ground granulated blast furnace slag (GGBFS) and fly ash. Different samples were prepared with different proportions of soil, GGBFS, and fly ash. Based on the result, the best compressive strength values were obtained in a 10% GGBFS and 10% fly ash mixture. This provides proof that the addition of GGBFS and fly ash can improve the clayey soil's mechanical properties. However, the soil strength value still does not comply the ASTM D 4609 standard, which requires a value greater than 0.8 MPa. To comply with the requirement, increasing the percentage of fly ash and GGBFS mixture proportions may be required.

Research performed in 2019 by Neeladharan et al. [16] investigated the possibility of stabilizing expansive soils through the use of a binder comprising of fly ash and ground granulated blast furnace slag (GGBFS).The clayey soil was mixed with different percentages fly ash of 5–25% and GGBFS of 2.5–10% by dry weight of soil. According to the results of the unconfined compressive strength test, a binder percentage of 20% is recommended as the optimal. However, the unconfined compressive strength value did not fulfill the ASTM D 4609 standard, which must be greater than 0.8 MPa. To fulfill the standard, increasing the percentage of fly ash mixture proportions and adding other ingredients such as GGBFS may be required.

Another study in 2014 by Oormila et al. [17] investigated the potential of using GGBFS as a stabilizer for the clay/soft soil. The soft soil was mixed with GGBFS at different percentages (15–25% by dry weight of soil) with curing times of 7, 14, and 21 days. The result indicates that the use of GGBFS increased the strength characteristics of the soil. Based on compressive strength, the optimum amount of GGBFS was 20%, as it increased the strength by about 73.79% of clayey soil. This provides proof that the GGBFS can improve the strength of the clayey soil. However, a long curing time is required to reach optimum strength. To reduce the curing time and increase strength, it may be essential to combine two types of precursors (fly ash and GGBFS) and increase the percentage of fly ash mixture proportions.

Research performed by Sharma et al. [18] investigated the possibility of utilizing a binder composed of fly ash and powdered granulated blast furnace slag to stabilize expansive soils (GGBFS). The expansive soil was mixed at different percentages of fly ash 70% and GGBFS 30% with curing times of 7, 14, and 28 days. Based on the strength result, the strongest soil was achieved after 28 days of curing time, with a compressive strength value of 0.45 MPa. However, the unconfined compressive strength value does not fulfill the ASTM D 4609 standard, which must be more than 0.8 MPa. Furthermore, a long curing time is required to reach optimum strength. To shorten the curing period and increase compressive strength, increasing the percentage of fly ash and GGBFS mixture proportions may be required.

III. CONCLUSION

The present study reviewed the effect of use of ground granulated blast furnace slag and marble waste dust in the soil. The detail review shows that the use of ground granulated blast furnace slag on soil helps to improve the engineering properties of soil i.e. compressive strength, split tensile strength, atterberg's limit etc. Similar effects can be seen by addition of marble waste dust in soil. From study it was also observed that there are very less findings on use of combination of Marble Waste Powder and ground granulated blast furnace slag together in soil. Therefore, this review proposed to study the effect of different composition of Marble Waste Powder and ground granulated blast furnace slag with soil.

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