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Evaluation Of Properties Of Soil Incorporating GGBFS And Waste Marble Powder

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Abstract: Collapsible soils are black cotton soils with extremely high shear strength when dry but rapidly lose strength when wet. Such rapid and significant loss of strength causes significant distress, resulting in extensive cracking and differential settlements, unstable building foundations, and even the collapse of structures built on these soils. Waste marble dust and Ground Granulated Blast Furnace Slag are industrial byproducts that are produced in massive quantities around the world and pose a threat to the environment. As a result, finding a long-term solution for its disposal is critical. The current study used a physio-chemical technique to reduce the collapse potential of black cotton soil. Because the soil is water-sensitive, it must be stabilised. Different percentages of waste marble dust (WMD) and ground granulated blast furnace slag (GGBFS) were used as an admixture. The effect of admixture on soil parameters such as specific gravity, plasticity index, swelling index, and shrinkage limit is investigated in this study. The study's optimization process revealed that adding waste marble dust improved the geotechnical parameters of black cotton soil significantly. Plasticity was reduced while Unconfined Compressive Strength (UCS) increased significantly. This research evaluates the safe disposal of hazardous waste and converts it into suitable material for engineering purposes.

I. INTRODUCTION

"Extensive soil is also known as Black Cotton soil due to its colour and suitability for cotton crop cultivation. The name'regur' for black cotton soil is derived from the Telugu word'reguda' The soil contains an abundance of calcium carbonate, potash, lime, and magnesium carbonate, but is deficient in phosphorus. [1-2] Black cotton soil is one of the largest regional soil deposits in India, covering approximately 3,000,000 square kilometres. Gujarat, Madhya Pradesh, and Maharashtra are its primary habitats.

Numerous geotechnical applications, including pavement constructions, highways, and building foundations, necessitate efficient and cost-effective expansive soil stabilisation. The stabilisation of expansive soil with admixtures reduces the soil's capacity for volume change and increases soil strength. This requires the use of inexpensive, affordable, effective, and easily accessible materials. To stabilise existing soil, we must use mineral admixtures such as fly ash, GGBFS, marble powder, iron slag, natural fibres, etc. GGBFS (Ground Granulated Blast Furnace Slag) and WMP (Waste Marble Powder) are byproducts of manufacturing. According to earlier studies conducted by a number of researchers, the use and disposal of GGBFS and WMP pose environmental difficulties. These wastes harm the fields and agricultural land. There may be a decline in land quality, soil characteristics, and mineral content. Utilizing industrial waste in the construction industry is therefore the best solution to their disposal issues. GGBFS and WMP can be used to stabilise black cotton soil (BC), thereby mitigating environmental concerns. Utilizing industrial waste in the construction industry is advantageous in a number of ways, including waste disposal, preserving bio diversity, enhancing soil qualities such as strength, permeability, etc., preserving natural soil, and constructing cost-effective structures. This project includes the GGBFS with WMP to investigate the impact of these materials on the soil quality in British Columbia. In this study, various tests were conducted on BC soil, including Specific Gravity, Compaction Test, California Bearing Ratio Test (CBR), and Unconfined Compression Test (UCS), using 5%, 10%, 15%, 20%, 25%, and 30% of GGBFS and WMP, respectively. Attempts have also been made to provide specific information on the changes in engineering properties of black cotton soil caused by the addition of admixture at varying percentages, and comparisons have been made. [3-5] The addition of GGBFS and marble powder to the soil may promote the formation of cementitious material.

Abdul Waheed et al. [6] are working on the Soil Improvement Using Waste Marble Dust for Sustainable Development project. When dry, collapsible soils have a very high shear strength, but when wet, they lose strength rapidly. This rapid and significant loss of strength causes significant distress, resulting in extensive cracking and differential settlements, instability of building foundations, and even the collapse of structures constructed on these soils. Waste marble dust is a byproduct of industry that is produced in enormous quantities worldwide and poses an environmental risk. Consequently, it is essential to find a permanent solution for its disposal. The current study focused on reducing the collapse potential of CL-ML soil via a physio-chemical approach. Due to its susceptibility to saturation, the soil must be stabilised. Variable amounts of waste marble dust (WMD) were utilised as an additive. The study's optimization method revealed that adding waste marble dust enhanced the geotechnical properties of collapsible soil significantly. Plasticity was diminished, but Unconfined Compressive Strength (UCS) increased significantly and edoema was reduced to an acceptable level. In addition, the California Bearing Ratio (CBR) has significantly improved. This study evaluates the safe disposal of hazardous waste and converts it into engineering-appropriate materials.

G. Tozsin et al. [7] examined the use of marble waste as a soil additive for neutralising acidic soil. The pH of the soil is one of the most important factors limiting plant growth. This study aims to evaluate the efficacy of marble waste applications in neutralising soil acidity. The efficacy of marble quarry waste (MQW) and marble cutting waste (MCW) in neutralising acid soil was determined through an incubation test in the laboratory. According to the results, MCW and MQW sprays increased the pH of the soil from 4.71 to 6.36 and 6.84, respectively. It was suggested that MQW and MCW could be used as soil additives to neutralise acidic soil, thereby reducing the negative environmental impact of marble wastes.

Sabat, A.K., and Nanda [8] examined the influence of marble dust on the strength and durability of expansive soil stabilised with rice husk ash. It provides a summary of the results of a laboratory investigation into the effect of marble dusts on the strength and durability of an expanding soil stabilised with the optimum proportion of Rice Husk ash (RHA). Based on Unconfined Compressive Strength (UCS) tests, 10% RHA was determined to be the optimal proportion. Marble dust was added to RHA-stabilized expansive soil in increments of 5% up to a maximum of 30% of the soil's dry weight. After seven days of curing, these samples were evaluated for compaction, UCS, Soaked California Bearing Ratio (CBR), swelling pressure, and durability. Marble dust increased the UCS and Soaked CBR of RHA-stabilized expansive soil by up to 20%. The addition of additional marble dust diminished these qualities. Regardless of the amount of marble dust added to RHA-stabilized expansive soil, the Maximum Dry Density (MDD) and Swelling pressure of expansive soil decrease, while the Optimal Moisture Content (OMC) rises. According to the results of the Durability test, the addition of marble dust strengthened the RHA-stabilized expansive soil. The optimal ratio of soil to rice husk ash to marble dust for the best stabilisation effect was discovered to be 70:10:20.

A.K. Sharma and P.V. Sivapullaiah [9] examine the use of fly ash treated with ground granulated blast furnace slag as an expansive soil stabiliser. This study investigates the possibility of stabilising expansive soils with a binder composed of fly ash and ground granulated blast furnace slag (GGBS). The combination of these two components to create a binder creates new avenues for enhancing pozzolanic activities, which may reduce swelling potential and increase the unconfined compressive strength of expansive clays. An investigation was conducted into the impact of varying binder percentages on the Atterberg limits, compaction properties, and unconfined compressive strength of an artificially mixed soil. The addition of a binder has been shown to significantly improve the quality of these soils. With the addition of a binder, the expansive soil's liquid limit and plasticity index decreased significantly, while its strength increased. Adding a minuscule amount of lime (one percent) to the soil enhanced its properties by boosting the pozzolanic reactivity of the binder. Based on the results of the unconfined compressive strength tests, it is advised that 20% binder be added as the optimal amount. In addition, mineralogical and morphological analyses of soil samples stabilised with optimal binder concentration revealed the formation of hydrated particles and cementitious compounds as a result of the clay-binder reaction. In addition to economic benefits, test results indicate that the use of GGBS mixed fly ash as a binder to stabilise expansive is well-suited for sustainable construction.

Pathak et al. [10] investigated the use of ground granulated blast furnace slag for soil stabilisation. Stabilisation is a broad term that refers to the various methods of altering the characteristics of a soil to improve its technical performance and suitability for use in a variety of engineering projects. Modern civil engineers are extremely concerned with soil stabilisation, both for road construction and for increasing the strength or stability of soil while reducing construction costs. This job involves stabilising the soil with ground granulated blast furnace slag (GGBS), a byproduct of iron production at a cement plant's blast furnace (from ACC plant, sindri).

Typically, it is offered in three forms: air-cooled, foamed, and granulated. Utilizing waste materials for stabilisation has environmental and economic benefits. Ground granulated blast furnace slag (GGBS) is used to stabilise soil in the current project (clay). The primary objectives of this study were to determine the effect of GGBS on the engineering properties of the soil (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) and the engineering properties of the stabilised soil. Granulated, shaped blast furnace slag is ideal for enhancing soil strength, and we examine the following soil characteristics. When GGBS is added from 0% to 25% by dry weight of soil, check and compare all soil properties at 0% (no GGBS) before adding 5% to 25% GGBS. The investigations revealed that the addition of GGBS improved the overall engineering qualities. The addition of GGBS led to a significant improvement across all test ranges for the programme. With increasing GGBS percentage, the maximum dry density increased while the optimal moisture content decreased, and the maximum dry density was attained at a moisture content of 25%.

Thomas, A., et al. [11] conduct soil stabilisation research using enzymes and alkali-activated ground granulated blast furnace slag. The development and application of non-traditional stabilisers for soil stabilisation, such as enzyme- and alkali-activated ground granulated blast-furnace slag (GGBS), contributes to the reduction of costs and negative environmental impacts. This study's objective is to compare the performance of alkali-activated GGBS and enzyme to conventional Portland cement (OPC) on Tilda, Chhattisgarh, India soil. Geopolymers are alkali alumino-silicates that are produced by combining a solid alumina-silicate with an aqueous alkali hydroxide or silicate solution. The effects of different stabiliser dosages on optimal moisture content (OMC), maximum dry density, plasticity index, unconfined compressive strength (UCS), and shear strength parameters were investigated. Additionally, the effect of the curing period has been investigated. The addition of stabilisers results in significant improvements in soil properties, including an increase in the OMC, UCS, and shear strength indices, as well as particle aggregation in stabilised soils. The addition of stabilisers dramatically increases the cohesiveness of the soil sample, while the angle of internal friction changes only marginally. Thus, the data indicate that non-conventional soil stabilisers, such as alkali-activated GGBS and enzyme, are more suitable and environmentally friendly than OPC for stabilising soil.

Mujtaba, H. [12] examined the application of ground granulated blast furnace slag to enhance the engineering properties of expansive soils. This study's primary objective is to improve the engineering characteristics of expansive soils by incorporating ground granulated blast furnace slag (GGBFS). Two large soil samples from DG Khan and Sialkot were collected for this purpose (Pakistan). According to the Unified Material Classification System, the soil sample from DG Khan was fat clay (CH), whereas the soil sample from Sialkot was lean clay (CL). To investigate its effect on soil stabilisation, varying amounts of GGBFS ranging from 0% to 55% were added to these soil samples. According to laboratory results on composite soil samples, the addition of 50 percent GGBFS to both samples increased the maximum dry unit weight by up to 10 percent. The California bearing ratio (CBR) increased from 3.2% to 11.5% for DG Khan soil and from 2.5% to 10.5% for Sialkot soil when 50% GGBFS was added. The addition of 30% GGBFS to DG Khan soil decreased the swell potential from 8% to 2%, whereas the addition of 20% GGBFS to Sialkot soil had the same effect but to a lesser extent (5% to 2%). With the addition of 30% GGBFS, the unconfined compressive strength of a sample that had been remoulded and cured for 28 days increased by approximately 35%. Combining GGBFS with expansive soil samples significantly improved their engineering properties, as demonstrated by the findings. It is also an efficient and eco-friendly method of disposing of steel industrial waste.

The purpose of this paper is to investigate the use of ground granulated blast furnace slag (GGBFS) and marble powder in equal proportions for the stabilisation of black cotton soil in varying percentages by weight of soil in order to assess the effect of this waste material on the engineering properties of soil.

2. Materials

The materials used for this study are Black cotton soil, Ground Granulated Blast Furnace Slag (GGBS) and Waste Marble powder .The properties are mentioned below.

2.1 Black Cotton Soil:

Black cotton soil refers to a type of soil that is expansive, black in colour, and capable of producing cotton. This type of soil expands abruptly when it comes into touch with water and then begins to inflate and shrink when the water is removed, making it a particularly troublesome soil for use as a building material owing to its swelling and shrinking characteristics.

The following are the properties of black cotton soil:

Table 2.1 Geotechnical properties of BC. Soil

Sr.No	Properties	Values
1	Soil classification	Black cotton soil
2	Liquid Limit (LL)	59%
3	Plastic Limit (PL)	3.947%
4	Plasticity Index (PI)	41.71%
5	Specific gravity (G)	2.1
6	Free Swell Index(FSI)	33.33
7	Optimum Moisture Content (OMC)	19.618 %
8	Maximum Dry Density (MDD)	1.642 gm/cc

2.2 Ground Granulated Blast Furnace Slag (GGBFS) :

These are the byproducts of the production of pig iron. The chemical makeup is comparable to that of cement. It is not a cementitious compound by itself, but it contains latent hydraulic qualities that can be activated by the addition of lime or alkaline material. Sherwood classified slag into three categories based on the method of cooling: air-cooled slag, water-cooled slag, and slag cooled by a combination of both air and water. After exiting the blast furnace, molten slag can be cooled slowly in the open air, resulting in crystalline slag that can be crushed and utilised as aggregate. Granulated slag including hot slag may result in vitrified slag production. Granulated blast furnace slag results from the use of water during the quenching process, whereas the use of air during the quenching process may result in Granulated slag information. Certain circumstances lead to the formation of expanded slag; stream created during the cooling of hot slag will give birth to expanded slag.

Fig 2.1: Ground Granulated Blast Furnace Slag Cement

Fig 2.2: Waste Marble Powder

2.3 Waste Marble Powder (WMP):

The dust generated by the cutting and grinding of marble has a very tiny particle size, is non-plastic, and is nearly well-graded. Traditional strategies for stabilising soil are plagued by high costs and environmental concerns. Alternately, soil enhancement using marble dust is the solution. The soil that has been stabilised with marble dust can be used for canal linings, pavement constructions, and foundations. This study intends to minimise the expansion of expansive soils via the use of marble powder and to observe the change in index characteristics of soil samples as the marble powder content increases

2.4 Specific Gravity

Specific gravity is the ratio of a given volume of a substance to an equivalent amount of liquid displaced. In the geotechnical profession, specific gravity is crucial. The specific gravity test was performed per IS: 2720 (Part 3): Sec 1-1980. Approximately 50 kg of dirt were collected for the specific gravity test. Take the pycnometer's empty weight and report it as W1. The pycnometer was stuffed with soil. Report the weight of the pycnometer as W2. After filling the bottle with distilled water, the bottle was put in a sand bath to eliminate air bubbles. After some time, remove the pycnometer from the sand bath and, while allowing it to cool, fill it to the mark. Report the weight of the pycnometer (soil and water) as W3. After that, fill the water to the specified level. Report the pycnometer and water weight using the W4 code. The soil's specific gravity is now calibrated according to the formula.

Fig. 2.3 Pycnometer Used For Specific Gravity Test

Fig. 2.4 LL test on admixed BC soil specimen

2.5 Liquid Limit

The liquid limit test was performed per IS: 2720 (part5)-1985. The soil that passed through a 425-micron filter was utilised for the experiment. In a tray, around 200 grammes of dirt are collected. Some water was combined with the dirt. Input of soil paste into the casagrande device. Using a groove, an incision was formed in the centre of the dirt. Along the diameter, the groove splits the dirt paste into two halves. After then, the device's handle was rotated. After a few rounds, the two portions will converge. Take a sample into a container to determine the moisture content. Notate the blows that coincide. Repeat the examination two or three times. Create a graph that compares blows to moisture content. Determine the relative humidity equivalent to 25 blows. It is described as a dirt liquid

2.6 Plastic Limit Test

For determining a soil's plastic limit, filter it with a 425 IS sieve. Approximately 30 grammes of dirt is mixed well with distilled water. Form a ball with 10 g of dirt that has been combined with water. Now, the ball was rolled with fingers against a glass plate. The shape of the ball transforms into a thread. Continue the technique until the thread is 3 mm in diameter. The pace of rolling was between eighty and ninety strokes per minute. Put the soil in a container to determine its moisture content. The moisture content at which soil thread begins to fracture was known as the plastic limit of the soil.

Figure 2.5 PL test on admixed soil specimen

2.7 Swell Index Test

Due to the presence of swelling-dominant clay minerals, such as the montmorillonite group, expansive soils are known to possess a high swelling capacity. It displays the results of black cotton soil swelling pressure for various enzyme dosages. The swelling pressure of untreated soil is 180 kN/m2, but the addition of enzymes (Terazyme) at varying dosages reduces the pressure to 160 and 40 kN/m2 after 7 and 30 days of curing, respectively. This suggests that when enzyme is added, the swelling pressure of the compacted soil decreases, making the material more stable. Consistently, after the addition of the enzyme, swelling potential diminishes with increasing amounts of stabiliser.

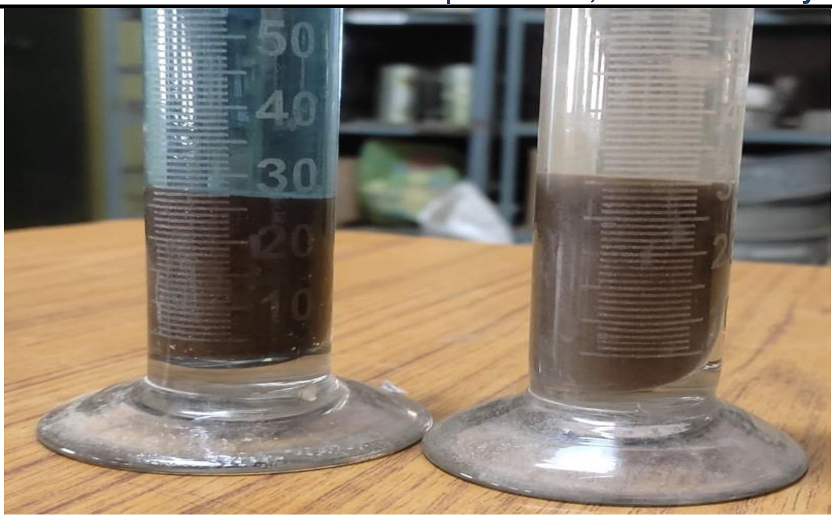

Figure 2.6 Swell index test on admixed soil specimen

3 Experimental Study

The tests were performed according to relevant ASTM and AASHTO Standards; the standard designations are referred to, where applicable..

3.1 Specific Gravity Test

From Table 3.1, the specific gravity values for BC-mixed soil may be determined. A detailed analysis of Table 3.1 indicates that the observed value of admixed soil's specific gravity was virtually identical to that of BC soil. According to IS (1498-1970), the acceptable specific gravity range is 2.20 to 2.50. Therefore, the specific gravity values observed in Table 3.1 for admixed soil samples are within the allowed range.

Table 3.1 Different Physical Properties based on admixed BC soil.

Sr. no	Sp. Gravity Test w.r.t admixed soil	Sp. Gravity	Shrinkage limit (%)	Plastic limit (%)	Plasticity index (%)	Swelling Index (%)	Degree Of Expansion
1	BC100MG0	2.10	8.2	30.947	41.71	33.33	Moderate
2	BC95MG05	2.27	13.3	29.443	38.15	23.68	Low
3	BC90MG10	2.22	13.3	28.434	35.59	18.52	Very Low
4	BC85MG15	2.35	13.2	26.966	31.03	17.26	Very Low
5	BC80MG20	2.35	14.9	22.527	28.47	16	Very Low
6	BC75MG25	2.32	16.7	24.557	20.44	0	No Expansion
7	BC70MG30	2.50	15	23.737	21.26	-4.16	No Expansion

3.2 Shrinkage Limit Test

The Shrinkage Limit Test was conducted in accordance with IS:2720 (Part 5)-1985. Table 3.2 displays the measured shrinkage limit values related to admixture replacement in BC soil. A detailed analysis of Table 3.2 indicates that the value of shrinkage limit for all admixed soil samples is essentially identical. Table 3.2 demonstrates that the addition of admixture to BC soil had no effect on the sample.

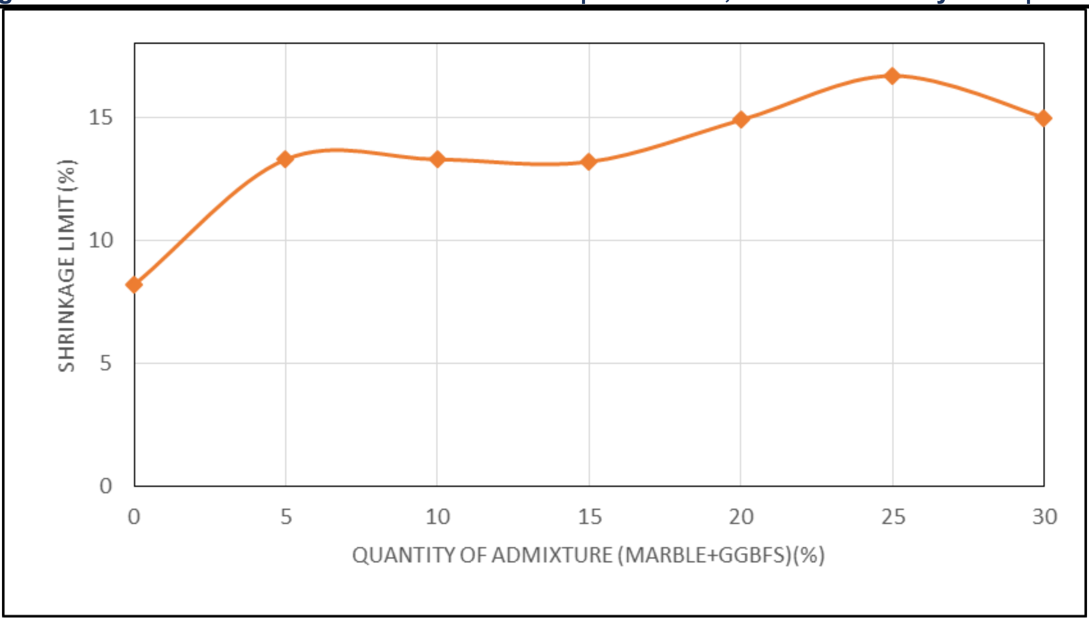

Fig 3.1 Graph on Shrinkage Limit V/S Quantity of Admixtur

3.3 Plasticity Index

The Plastic Limit Test was conducted in accordance with IS:2720 (Part 5)-1985. Table 3.3 displays the observed values of Plastic limit related to admixture replacement in BC soil, as well as their plasticity index. Table 3.3 demonstrates that the observed value of the plasticity index of admixed BC soil decreased. Typically, a decrease in the plasticity index is employed to measure the efficacy of (GGBFS+ WMP) treatment on BC soil.

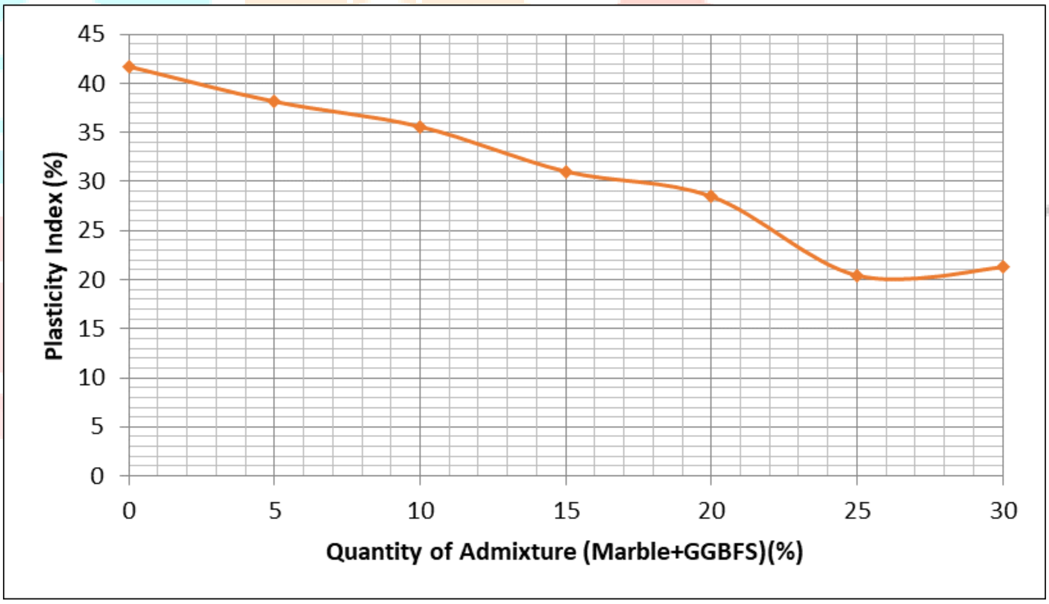

Fig 3.2 Graph on Plasticity index V/S Quantity of Admixture

3.4 Free swell index

Method C under ASTM D4546 has been utilised to determine the swell percentage. The outcomes are presented in table 3.4. As the fraction of GGBFS+WMP increases, the differential free swell index values are seen to decrease. Table 3.4 demonstrates that the proportion of swelling index decreases radially. The proportion of additives from 0 to 20% causes a substantial fall in the swell index, after which the admixed BC soil expands to zero. Negative values of the swell index are referred to as ashydrocollapse. According to ASTM D4546 Test Method C, sample disruption of non-expanding or expansive soil might also result in negative readings

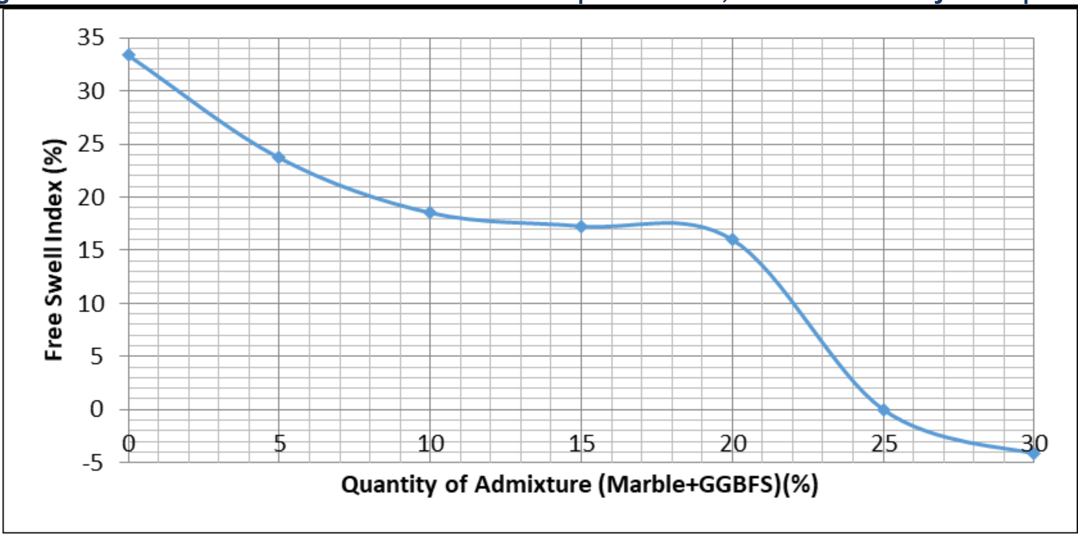

Fig 3.3 Variation In Swelling Index By Treated BC Soil.

3.5 Unconfined Compressive Strength

The impact of the addition of GGBFS and Waste Marble Powder to a sample of black cotton soil on the UCS Value as well as the percentages of OMC and MDD obtained by the SPCT Test. It demonstrates that the UCS of the black cotton soil sample increases with the addition of different proportions of admixture, up to a specific limit.

3.5.1 UCS test based for 0 days

The USC examinations were conducted. Blocks containing various combinations of Black Cotton soil, discarded Marble Powder, and Ground Granulated Blast Furnace Slag were fabricated. The proportion of GGBFS and Waste Marble Powder in the Black cotton soil mixture varied between 0% and 25%. The 150mm long block with a 50mm diameter was constructed. The testing was performed using a Universal Testing device. The testing was performed on day zero. The results are displayed in the table below. Each deformation of 0.5 mm was accompanied with a readout. It has been shown that, as strain increases, so does the stress created in the material. The information is depicted in the graph below. As demonstrated in the graph below, as the percentage of GGBHS+WMP in the block grows, so does the stress caused. The UCS increases as the proportion combination increases. Pure black cotton soil induces the least amount of UCS, whereas 25% admixtures after 0 days of curing generate the greatest amount of UCS. Upon 0 days of curing, the highest induced UCS is 66.24 MPa, 70.88 MPa, 75.84 MPa, 81.15 MPa, 86.83 MPa, and 92.91 MPa for combinations of 0%, 5%, 10%, 15%, 20%, and 25% admixtures, respectively.

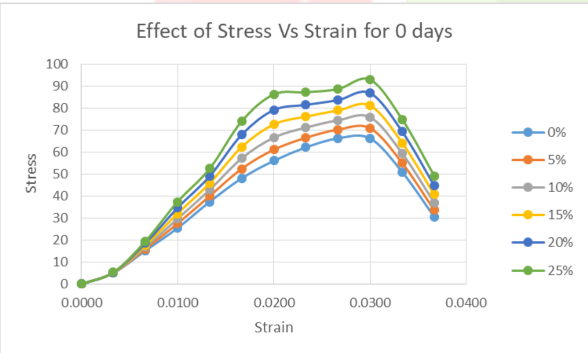

Fig 3.4: Stress Strain Data of UCS Test of 0 days for different percentage of admixtures

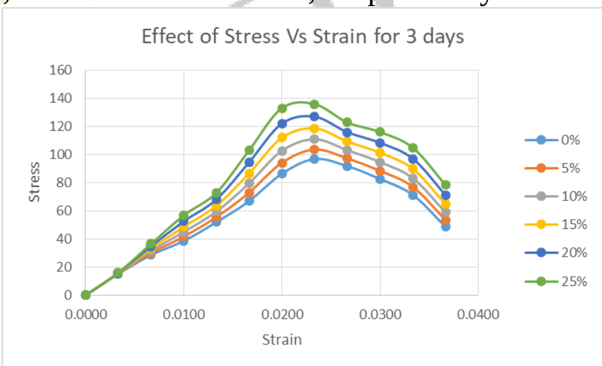

Fig 3.5: Stress Strain Data of UCS Test of 3 days for different percentage of admixtures

3.5.2 UCS test based for 3 days

The USC tests were conducted. Mixing varying proportions of ground-granulated blast furnace slag, leftover marble powder, and black cotton soil produced the block. 0% to 25% of the Black cotton soil combination contains GGBFS and Waste Marble Powder. A 150mm-long, 50mm-diameter block was produced. On a Universal Testing machine, tests were conducted. Three days following the treatment, testing was conducted. The outcomes are shown in the table below. Every 0.5mm of deformation resulted in a measurement being taken. It was discovered that when the strain grew, the material's stress also increased. The graph below displays the specific data. The graph below depicts how stress induction rose as the proportion of GGBHS+WMP in the block grew. The UCS increases as the proportion combination increases. Pure black cotton soil displays the least amount of UCS-induced stress, whereas 25% admixtures exhibit the most stress after 3 days of curing. The greatest induced UCS reported after 3 days of curing for combinations of 0%, 5%, 10%, 15%, 20%, and 25% admixtures is 96.81 MPa, 103.59 MPa, 110.84 MPa, 118.60 MPa, 126.90 MPa, and 135.78 MPa, respectively.

3.5.3 UCS test based for 7 days

The USC tests were conducted. Mixtures of Black Cotton soil, discarded Marble Powder, and Ground Granulated Blast Furnace Slag were used to create a block. 0% to 25% of GGBFS and Waste Marble Powder were present in the Black cotton soil combination. A block with a 50mm diameter and 150mm length was created. A Universal Testing Machine was used to conduct the tests. Testing was conducted after seven days after curing. The results are displayed in the table below. Every deformation of 0.5mm produced a reading. It was revealed that as the strain grew, so did the material's internal tension. The details are displayed in the graph below. The graph below indicates that as the proportion of GGBHS and WMP in the block increases, so does the resulting stress. The UCS value increases as the percentage combination increases. Pure black cotton soil causes the least amount of UCS, but 25% admixtures after seven days of curing produce the maximum stress. After 7 days of curing, the greatest induced UCS for 0%, 5%, 10%, 15%, 20%, and 25% admixtures is 101.91 MPa, 109.04 MPa, 116.67 MPa, 125.51 MPa, 136.80 MPa, and 149.11 MPa, respectively.

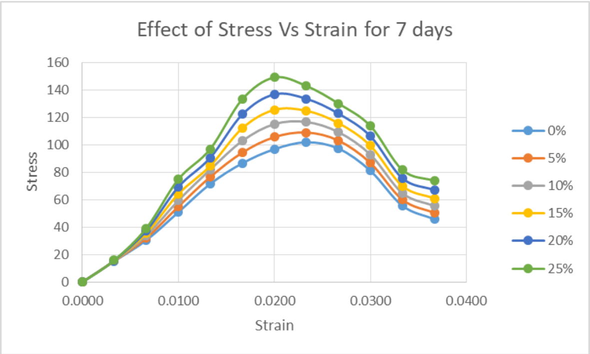

Fig 3.6 : Stress Strain Data of UCS Test of 7 days for different percentage of admixtures

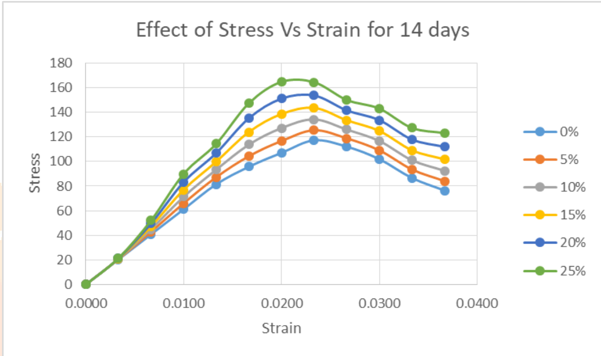

Fig 3.7: Stress Strain Data of UCS Test of 14 days for different percentage of admixtures

3.5.4 UCS test based for 14 days

The USC exams were administered. Various mixtures of Black Cotton soil, wasted Marble Powder, and Ground Granulated Blast Furnace Slag were utilised to create blocks. In the Black cotton soil combination, the proportions of GGBFS and Waste Marble Powder ranged from 0% to 25%. The 150mm long, 50mm in diameter block was constructed. The testing was conducted using a device for Universal Testing. Testing was conducted fourteen days following the treatment. The outcomes are shown in the table below. Each 0.5 mm deformation was accompanied with a reading. It has been demonstrated that when strain grows, so does the material's stress. The data is represented in the graph below. As seen in the graph below, as the proportion of GGBHS+WMP in the block increases, so does the resulting stress. As the percentage combination grows, so does the UCS. After 14 days of curing, pure black cotton soil produces the least UCS, whereas 25% admixtures create the most stress. 14 days after curing, the greatest induced UCS for 0%, 5%, 10%, 15%, 20%, and 25% admixtures is 117.20 MPa, 125.40 MPa, 134.18 MPa, 153.62 MPa, and 164.64 MPa, respectively.

3.5.5 UCS test based for 28 days

The USC testing have been completed. The block was composed of mixtures of Black Cotton soil, discarded marble powder, and pulverised granulated blast furnace slag. 0% to 25% of GGBFS and Waste Marble Powder were used in the Black cotton soil combination. The 150mm-long, 50mm-wide block was manufactured. The tests were conducted with a Universal Testing equipment. After curing for 28 days, the tests were conducted. The outcomes are listed in the table below. Every 0.5mm of deformation resulted in a reading. It has been observed that as the strain increased, so did the material's stress. The data is displayed in the graph below. As the percentage of GGBHS+WMP in a block increases, so does the stress it creates, as seen by the graph below. As the proportion combination rises, so does the UCS. After 28 days of curing, pure black cotton soil causes the least UCS, whereas 25% admixtures create the maximum UCS. After 28 days of curing, the highest induced UCS for 0%, 5%, 10%, 15%, 20%, and 25% admixtures is 127.39 MPa, 136.31 MPa, 145.85 MPa, 156.06 MPa, 166.98 MPa, and 178.68 MPa, respectively.

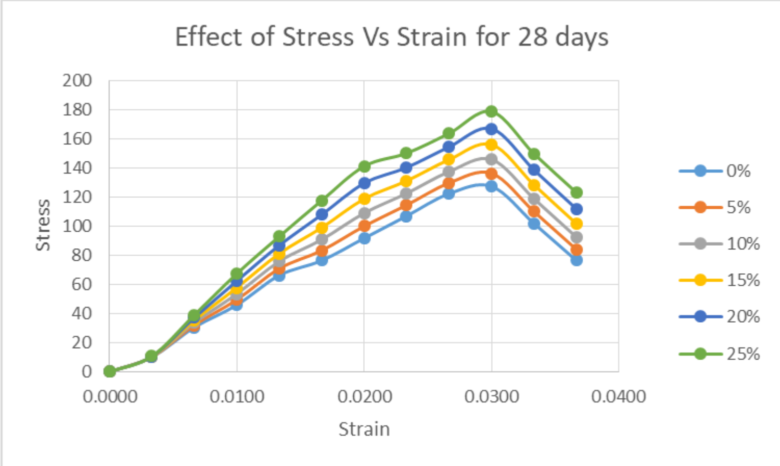

Fig 3.8: Stress Strain Data of UCS Test of 28 days for different percentage of admixtures

4. Conclusion

From the above study, the following conclusions are drawn based on the performance of the admixed Black Cotton Soil:

1. From the combination of GGBFS and WMP used in BC soil the different properties of soil are find outs.
2. Sp. Gravity was found to be in the range of 2.1 to 2.5. It is increasing as the percentage combination of GGBFS and WMP increases in black cotton soil.
3. The shrinkage limit has been tested. It was found to be in the range of 8.2% to 15%. It is increasing as the percentage combination of GGBFS and WMP increases in black cotton soil.
4. The plastic limit and plasticity index has been tested. It was found that, the range of plastic limit is 23.73% to 30.94% and plasticity index in the range of 21.26% to 41.71%. It is decreasing as the percentage combination of GGBFS and WMP increases in black cotton soil.
5. The swelling index has been tested. It was found that, swelling index in the range of 33.33% to -4.16%. It is decreasing as the percentage combination of GGBFS and WMP increases in black cotton soil.
6. The variation in GGBFS and WMP content shown maximum UCS value at the replacement level of 5% and 10%. Unconfined compressive strength of admixed soil specimen increased by 35.71% with the increase in WMP content and GGBFS and found maximum UCS value at proportions 5 and 10 percent of GGBFS+WMP in equal proportion.
7. The maximum unsoaked CBR and UCS value obtained after stabilization with GGBFS and WMP was increased significantly as the replacement level increased.

References

1. Yilmaz, F. and Yurdakul, M.U.H.A.M.M.E.T., 2017. Evaluation of marble dust for soil stabilization. *Acta Physica Polonica A*, *132*(3), pp.710-711.
2. Priyanka Shaka, P. G. Rakaraddi,"Experimental study on the Effect of Bio-Enzyme Stabilization on Black Cotton Soils and Red Soil",IJIRSET: Vol. 5, (2016)
3. Lacuoture, A. & Gonzalez, H, "Usage of organic enzymes for the stabilization of natural base soils and sub-bases in bagota".Pontificia Universidad Jevariana, Faculty of Engineering,(1995)
4. Isaac, K.P., Biju, P.B. and Veeraragavan, A,"Soil stabilization using bioenzyme for rural roads". IRC Seminar: Integrated development of rural and arterial road networks for socio-economic development, New Delhi, 5-6 December, (2003).
5. Swathy M Muraleedharan And Niranjana.K,"Stabilisation Of Weak Soil Using BioEnzyme" International Journal Of Advanced Research Trends In Engineering And Technology (ijartet) vol.II, special issue x, march 2015 in association with holy grace academy of engineering organizes national level conference on innovative engineering (16-20th march 2015),(2015)
6. Waheed, A., Arshid, M.U., Khalid, R.A. and Gardezi, S.S.S., 2021. Soil improvement using waste marble dust for sustainable development. *Civil Engineering Journal*, *7*(9), pp.1594-1607.
7. Tozsin, G., Arol, A.I., Oztas, T. and Kalkan, E., 2014. Using marble wastes as a soil amendment for acidic soil neutralization. *Journal of environmental management*, *133*, pp.374-377.
8. Sabat, A.K. and Nanda, R.P., 2011. Effect of marble dust on strength and durability of Rice husk ash stabilised expansive soil. *International journal of civil and structural engineering*, *1*(4), pp.939-948.
9. Sharma, A.K. and Sivapullaiah, P.V., 2016. Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer. *Soils and Foundations*, *56*(2), pp.205-212.

10. Pathak, A.K., Pandey, V., Murari, K. and Singh, J.P., 2014. Soil stabilisation using ground granulated blast furnace slag. *Int. J. Eng. Res. Appl*, *4*, pp.164-171.
11. Thomas, A., Tripathi, R.K. and Yadu, L.K., 2018. A laboratory investigation of soil stabilization using enzyme and alkali-activated ground granulated blast-furnace slag. *Arabian Journal for Science and Engineering*, *43*(10), pp.5193-5202.
12. Mujtaba, H., Aziz, T., Farooq, K., Sivakugan, N. and Das, B.M., 2018. Improvement in engineering properties of expansive soils using ground granulated blast furnace slag. *Journal of the Geological Society of India*, *92*(3), pp.357-362.