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Stabilization of Black Cotton Soil Using Various Admixtures: A Review

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Abstract: This paper reviews the effect of various admixtures in view of increasing strength and reducing deformation characteristics of black cotton soil from studies carried out by different researchers. Stabilization of black cotton soil is targeted at providing stable and durable engineering structures. It becomes necessary when materials intended for foundation and pavement construction failed to meet the requirement in civil engineering practice. Black cotton soil from north-eastern part of Nigeria and different locations around the world are mostly classified as A-7-6 soils by American Association of State Highway and Transportation Officials (AASHTO); CH high plasticity clay soils by Unified Soil Classification System (UCSC) and high swell potential BCS by Nigerian Building and Road Research Institute (NBRRI). Experiment conducted include; Atterberg's Limits, Specific Gravity, Sieve/hydrometer Analysis, Free Swell, Compaction, Triaxial, Shear Box, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR) tests. Soil characteristics such as the maximum dry density (MDD), optimum moisture content (OMC), CBR values, shear strength, cohesion, and angle of internal friction were improved significantly by admixtures such as lime, cement, E-waste, reclaimed asphalt pavement, and steel mill ore, while admixtures such as groundnut ash, bagasse ash and plantain peel powder demonstrated unsatisfactory improvement when used as standalone. Thus, it can be concluded that black cotton soil when stabilized with admixtures such as lime, cement, reclaimed asphalt pavement, E-waste, and still mill ore can be used in foundation and pavement construction. This study finally recommends the supplementary use of weak admixtures with some rather cementitious material to achieve a strong and durable foundation.

Keywords: Stabilization, Black Cotton Soil, Admixtures

1. Introduction

Due to changes in moisture, black cotton soils are prone to unfavourable volume changes [21]. These are the residual deposits of lava or rockfalls, which mainly occupy arid and semi-arid areas and a large part of the world. The soil is problematic for civil engineering construction. The existence of montmorillonite is the main reason for the effective water content of the soil and the shrinkage and expansion behaviour of the soil. It is the cause of many problems, such as ground-related road damage and excessive subsidence [13]. Over the years, various attempts by researchers to improve the swelling and shrinkage behaviour and strength characteristics of soil have proven themselves.

2. Literature Review

2.1. Stabilization of Black Cotton Soil Using Chemical Admixtures

2.1.1 Stabilization of Black Cotton Soil Using Lime as Stabilizer

Singh [35] While studying the effect of lime on geotechnical properties of the black cotton soil established that the properties of the soil can stabilized by varying proportions of lime. It was found that the liquid limit increases by almost 12.1% at 4% lime content addition. A decrease of nearly 17.1% was observed at 6% lime addition. The M.D.D. was found to decrease by 2.4% and 5.6% at 4% and 6% lime content respectively. The C.B.R. value of black cotton soil mixed with 4% and 6% lime at 2.5 mm penetration indicated a consistent improvement. At 5.0 mm penetration, the increase in C.B.R value also increased consistently. This shows that lime can be used to stabilized deficient soil.

Hegde [16], determined that when lime is applied to black cotton soil, a pozzolanic reaction occurs, leading to stability. The hydrated lime combines with clay particles to transform them into a strong cement matrix that is durable. The basic parameters of the soil were determined using black cotton soil with low to medium swelling potential. Plastic limit, Liquid limit, MDD, OMC, free swelling, swelling pressure, and California bearing ratio were determined. Adding lime to swelling soil immediately reduces the soil swelling potential when it comes in contact with water. As the concentration of lime in the soil increases, the plasticity of the soil decreases and the stiffness of the soil increases. The optimum lime percentage used in the study to improve the strength properties was observed to be 3.5% to 4.5%.

Amruta [7] have discovered that adding 6% lime to black cotton soil reduces its flexibility, shrinkage, and swelling qualities significantly. When wet, the compressive strength rises to around 15.22 kg/cm^2. CBR values increase from 3.3 percent of virgin soil to approximately 62.8 percent. The treated black cotton soil can be used safely as a sub-grade, sub-base, or base material, reducing the thickness of a road's upper crust made of an expansive material such as hard stone.

2.1.2. Stabilization of Black Cotton Soil Using Lime and Other Material as Stabilizers

Ikeagwuani [18] Investigation indicates that black cotton soil may be well stabilized to be used as subgrade material. Adequate strength was accomplished with 16% SDA and 4% lime content. The significance of the outcomes is that in contrast to other lime stabilization instances in where higher proportions of lime is required for the optimum stabilization of expansive clays, desirable effects were accomplished at just 45 lime and 16% SDA addition. The CBR value of 20.64% meets the standards of Nigerian General Specification for Roads and Bridges (1997).

Annafi [7] Experimented with the influence of mixing time on the strength qualities of lime and iron ore tailings on black cotton soil as a subgrade material. The soil was stabilized with 0, 2, 4, 6, 8, and 10% lime and 0, 2, 4, 6, 8, and 10% Iron ore trailing content. Atterberg limits, compaction, unconfined compressive strength (UCS), California bearing ratio (CBR) tests were performed to investigate the effect. Statistical analysis was carried out by MINI-TAB software. There was a decrease in liquid limit of the mixes as the lime and IOT content increased according to the findings. After mixing, the liquid limit of all the treated Black Cotton Soil increased in an hour. The plastic limit (PL) of the soil on the other hand, dropped as additives content increased. Between 0 and 2 hours after mixing, the Unconfined Compressive Strength and California Bearing Ratio values rose as the additives content increased. For all lime content evaluated, peak values were observed for the 8 per cent lime and 8 per cent Iron Ore Trailing treatment.

S. Srikanth [33] Established that Lime stabilization improve the strength characteristics of the black cotton soil to the point where it could be used as a subbase material. The maximum dry density and optimum moisture content improved at 20% and 80% mixture of brick powder and lime additive respectively. Lime and brick powder-stabilized black cotton soil increased the soaked CBR value by roughly 135 percent, making it suitable for use as subbase material. The use of brick powder minimizes the lime content in the mix, which in turn reduces the project's cost because of the availability of brick powder. It also decreases community sanitation problems.

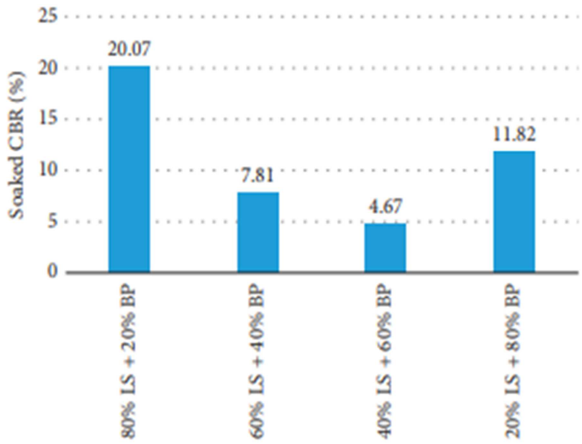

Figure 1. *Various mix proportion of lime-stabilized black cotton soil and brick powder.*

As a result, suitable subgrade material can be obtained by stabilizing black cotton soil with lime and brick powder additives.

Ikeagwuani [18] Tried to improve the strength characteristics of black cotton soil. The study employs the use of palm kernel shell ash and lime additives to investigate effects on black cotton soil. From the analysis made in the paper, it was established that the addition of lime and palm kernel shell ash to natural soil reduces the maximum dry density while raising the composite mixture's optimum moisture content. When natural black cotton soil was mixed with 4 percent lime and 8 percent palm kernel shell ash by weight, the maximum CBR value of 10.2 percent (unsoaked) and 5.1 percent (soaked) was obtained.

Ikeagwuani [19] The study looked at the compressibility characteristics of sawdust ash and lime-stabilized black cotton soil in an attempt to find a solution. The soil was subjected to consolidation to drive out moisture. The tests conducted were Atterberg limits, specific gravity test, and sieve analysis to determine the particle distribution. The additive was varied in percentages of 0, 4, 8, 12, 16, and 20% by weight of black cotton soil, while a constant lime of 4% by weight of dry soil was also added to all the mixed samples. The settlement characteristics of black cotton soil were significantly enhanced when 16 percent Saw Dust Ash and 4 percent lime of the weight of black cotton soil was mixed.

2.1.3. Stabilization of Black Cotton Soil Using Cement and Other Materials

Ibrahim [17] Performed an analysis on twenty (20) disturbed soil samples of ordinary Portland cement stabilized black cotton soil. The additives were added at increasing percentages of 2, 4, 6, and 8 and waste glass at increasing percentages of 5, 10, 15, and 20 blend at optimum moisture content. Statistical regression correlates the soaked California Bearing Ratio values with some measured soil characteristics. Maximum dry density MDD, waste glass WG, cement content Cm, liquid limit LL, and plastic limit PL were employed as independent variables, and it was observed that that the variables for both prediction models and compactive of the CBR are pretty near to the corresponding real findings.

Sajja [34] used cement lime and rice husk to stabilized black cotton soil, it was established that that at optimum dosage, Free swell index of black cotton soil was improved by 85%, Plastic limit by 12.35%, Liquid limit by 56.35%. Plasticity index for black cotton soil by 44.50%. The Soil been classified as CH (Inorganic Clays of high plasticity) By AASHTO, The OMC and MDD values were determined as 28.5% and 1.51 g/cc respectively.

Paul [30] Studied how black cotton soil (BCS) stabilized by the use of iron ore tailings (IOT) and cement react to various compaction efforts. British standard light compaction For various percentages of iron ore tailings and cement was conducted (0-10%), the optimum moisture content values of 21.2, 20.8, 20.5, 20, 20.3, and 20.2 percent were observed. Higher cement concentrations and compactive efforts followed the same pattern. Using software, regression models, Regression analysis reveals that the independent factors studied have a significant impact on the dependent variables. The amounts of cement and IOT contributions to the improvements were determined using ANOVA (analysis of variance). As a result, for soil rehabilitation or geotechnical engineering applications, black cotton soil treated with a 4 percent cement 10 percent IOT blend and compacted with British Standard Heavy energy produce the optimum strength.

Prathap [32] Investigates cement kiln dust (CKD) effect on black cotton soil, the cement kiln dust is a waste product from the cement industry, it was used as a stabilizing material for black cotton soil (BC soil) in the study. Characterization of Black Cotton soil for Atterberg's limits, Specific gravity, pH, compaction properties, and unconfined compressive strength was carried out in the study by admixing with CKD at various percentages. According to the findings of this study, both the liquid and plastic limits increase as the percentage of people with CKD rises. For BC soil admixed with 12 percent CKD, it was discovered that UCS increases as the curing period increases. Because CKD is an industrial waste, it can be utilized to stabilize BC soils and improve their engineering performance. With an increase in CKD%, both the liquid and plastic limits increase. When the percentage of people with CKD exceeds 12 percent, the plasticity index decreases. When CKD levels were between 4% and 8%, the pH of CKD admixed BC soil showed a modest rise in pH. After that, the pH drops and stabilizes beyond the 12 percent CKD mark. The maximum dry density of BC soil admixed with 12 percent CKD increased significantly, with a corresponding fall in OMC optimal moisture content, which is ideal. The highest UCS value was found in BC soil that has 12 percent CKD admixed in it. For BC soil admixed with 12 percent CKD, it was discovered that UCS increases as the curing period increases. As a result, it was determined that 12 percent CKD provides the best results in terms of reducing plasticity and increasing strength in BC soil admixed with CKD.

Shreyas [36] established that addition of some percentage of cement together with fly ash increased the strength properties of Black Cotton soil which in turn increase its stability. California bearing test was conducted by varying proportion of admixtures, it was observed that there is an improvement in the CBR values with the increase in percentage of admixtures (cement and fly ash). It has been found that with the increase in percentage of M-sand with cement & fly ash there is an increase in Maximum dry density and significant decrease in optimum moisture content of the soil.

Ahmad [3] studied, the efficiency of black cotton soil combined with ordinary Portland cement (OPC) and treated bone ash for soil strength investigation. The goal of the study was to improve the strength of black cotton soil by mixing bone ash with conventional Portland cement and determining the optimal proportion that may be utilized as a low-cost road construction material. At 6 percent OPC/6 percent BA treatment on the Black Cotton Soil, the properties was found to be suitable for subbase material according to the findings. combustion by crushing the bone to powder as an additive.

Dogo [1] Found that of Rice Husk Admixture in black cotton soil enhanced the soil's Unified Compression Strength in the results of the laboratory experiment conducted. Cement was used as admixture, and the Unconfined Compression Strength values decreased as the amount of cement increased, and increased with increase in rice husk admixture content. A black cotton soil stabilized using 3 percent cement, 3 percent rice husk admixture, and 1 percent promoter achieves the highest compressive strength. From the experiment, It can also be deduced that mixing Rice Husk Ash with soil boosts its unconfined compressive strength and shifts the soil's failure mode from brittle to ductile.

Anigilaje [6] While studying the compactive efforts, up to 10% cement kiln dust was mixed with Black cotton soil, utilizing British Standard heavy (BSH), West African Standard (WAS British Standard light (BSL). The qualities of the soil improved in general after cement kiln dust was added, according to the results of laboratory testing on soil specimens. At 10% cement kiln dust addition was the optimum. It was observed that for the various compactive energies, the unconfined compressive strength (UCS) values were 357.07, 382.49, and 528.82 kN/m2 for British Standard Light, West African Standard, and British Standard Heavy respectively, as well as CBR which was obtained to be 7, 10, and 19 per cent. When the samples were examined by electron microscope, reduction in particle sizes was observed at the curing period progressed. According to the findings, cement kiln dust may be used to stabilized black cotton soil.

Osinubi [21] studied Black cotton soil treated with a blend of ordinary Portland cement and locust bean waste ash in a stepwise proportion of 0, 2, 4, 6, and 8 per cent each by dry weight of soil. The three criteria for evaluating strength (UCS, CBR, and Durability) were evaluated when compaction was done using British Standard light compaction was employed. When curing for 7, 14, and 28 days, the Unconfined Compressive Strength values of specimens treated with 6 percent OPC / 6 percent Locust Bean Waste Ash improved from initial of 178, 381 and 760kN/m2 for the natural soil to 986, 1326, and 1348kN/m2, respectively. The CBR value of 42 percent was recorded for the 6 percent Ordinary Portland Cement / 6 percent optimum Locust Bean Waste Ash stabilization. percent for the 6 percent OPC / 6 percent LBWA treatment. The blend's strength and durability improved with curing ages, showing that it has the potential for a further increase in strength characteristics.

2.1.4. Stabilization of Black Cotton Soil Using Sodium Silicate

Ola [26] Sampled black cotton soils from different locations in North-Eastern Nigeria. It was established that soil from that location contain high clay and silt proportions. The flexible pavements are exposed to danger of swell-shrink potential which bring about cracks and subsequent failure of the pavements in the locals. Acrylic copolymer was used in the study to stabilized the collected soil and it was found to be effective in increasing the geotechnical characteristics by reducing the plasticity, swelling and shrinkage properties of the soil. It was concluded that the acrylic copolymer can be used widely to stabilized unsuitable soils for engineering constructions.

Pramod [31] Studied the blend of lime and Envirobase sodium silicate and to see their effects on geotechnical features of black cotton soil. Laboratory experiment were conducted such as compaction and California bearing ratio to determine the soil properties. The mixing of Envirobase to the black cotton soil significantly boosted the California bearing ratio, while on the other hand, sodium silicate increment with lime decreases the soil's plasticity index. The mixing of sodium silicate with lime together with the soil decreases the liquid limit. When 1 percent Envirobase is added to the liquid limit, it remains steady and then decreases when the proportion of Envirobase is increased. Because sodium silicate with lime is inexpensive and readily available, it can be utilized as a local stabilizer in modest building projects. For Envirobase to be used, the construction project must be huge, and Envirobase is one of the best soil stabilizers for highway and airfield development.

2.2. Stabilization of Black Cotton Soil Using Organic Chemical Admixtures

2.2.1. Stabilization of Black Cotton Soil Using Plantain Peel Powder

Oluwafemi [27] Examine the effects of plantain peel powder (PPP) on black cotton soil. Because of the impact of montmorillonite which has an extensive lattice, BCS are considered to be an extended soil and largely disposed to volumetric variations in moisture. In the study, plantain peel powder (PPP) was employed to stabilize the Black cotton soil, which was acquired from Yola, Adamawa state, Nigeria. The Black cotton soil was stabilized in proportions of 0, 2, 4, 6, 8, and 10 percentages. Several laboratory tests, such as gradation test, Natural Moisture Content, Linear Shrinkage, Specific Gravity, Plastic Limit, and Liquid Limit to establish the Engineering characteristics of the BCS when stabilized with PPP. The percentage of soil passing sieve 200 is higher than 35%,). The effect of Plantain peel powder on engineering properties revealed that for 0 to 10 Plantain peel powder admixture, the liquid limit percent, plastic index varied between 48 and 32 for liquid limit percentages, 28 and 13 for plastic index percent, and 14 and 7.5 for Ls percent, indicating that the Plantain peel powder reduces the clay content and improve the engineering. It was discovered that mixing Plantain peel powder with BCS improves the engineering characteristics of the sampled BCS. As a result, Plantain Peel Powder (PPP) is ideal for stabilizing roadwork materials if supplemented with stronger admixture.

2.2.2. Stabilization of Black Cotton Soil Using Polyvinyl Acetate

Oluyemi [9] sampled some soil from six different places across the country, and their geotechnical qualities were assessed in both their natural and stabilized states. The tensile parameters of the soil samples improved significantly when they were mixed with polyvinyl acetate. All of the samples were boosted from unsuitable base materials to suitable one, according to the CBR data. By stabilizing with this material, some of the country's inappropriate commonly available soil resources could be used for road operations, assisting in the supply of decent road networks in the regions.

Oyekan [11] Conducted an experiment which reveals the impact of polyvinyl waste on the engineering properties of black cotton clay soil. To determine the soil stabilizing potentials, the soil was combined the admixture at 5, 10, 15, 20, and 30% content. With an increase in ground polyvinyl waste content, both the soaked and unsoaked California bearing ratio (CBR) rose. At 30% admixture content, the unconfined compressive strength was improved by nearly 60%. The CBR of the drenched CBR rose by around 20%, whereas the CBR of the un-soaked CBR climbed by nearly 50%. The findings suggest that using ground polyvinyl waste to improve black cotton soils has a significant effect.

Jayaganesh [20] Established that when polymeric resins are added to soil, the specific gravity values rise. Poly vinyl alcohol and Epoxy resin have the highest specific gravity of the three polymeric resins, at 15%. The increment of 15% resin to the soil was discovered to reduce the liquid limit values and plasticity index, resulting in a reduction in plasticity characteristics. Epoxy resin has a lower plasticity index value than other polymers. As a result, the decrease in plasticity index as a result of the increment of the resin is a favorable and appealing occurrence. Swelling potential is greatly countered when polymeric resins were added, and

Epoxy resin, in particular, has a nil value, i.e. zero at 15%. Polyvinyl alcohol offers a greater CBR value up to a 15% addition to soil. It is clear from the test findings that polymeric resins improve the engineering properties of the soil, lowering the plasticity index and swelling potential while increasing specific gravity and CBR. Epoxy resin was determined to be the most efficient of the three polymeric resins because at 15%, it drastically decrease the plasticity index and swelling potential resulting in a reduction in soil plasticity characteristics.

2.2.3. Stabilization of Black Cotton Soil Using Groundnut Shell Ash

Oriola [29] found the peak soaking CBR values of 4% at SP and 4% at WA at 6 percent (GSA) and 0 percent (GSA), respectively. These figures fell short of the CBR's specified requirements. base or sub-basic material value The specimen's durability, as measured by resistance to loss of strength, does not meet the necessary 80% resistance to loss of strength for 7-day cured and 4-day soaked samples. As a result, groundnut shell ash cannot be used to stabilize black cotton soil. According to the records of the 7, 14, and 28 days cured unconfined compressive strength of specimens, groundnut shell ash displayed improvement in strength with longer periods of curing.

Ijimdiyaa [38] Established that, for base course material, Groundnut ash treated soil fail short of the reequipment of Nigerian Building and Road Research Institute (NBRRI). 6% CBR was found to be the optimum at 8% Groundnut shell ash. The obtained value does not fulfill the specified subgrade material requirement. The unconfined compressive strength of 1034.25kN/m2 was obtained at 7 days which is also lower than the TRRL (1977) requirement. As a result, it is suggested that groundnut shell ash cannot be used as a standalone stabilizer.

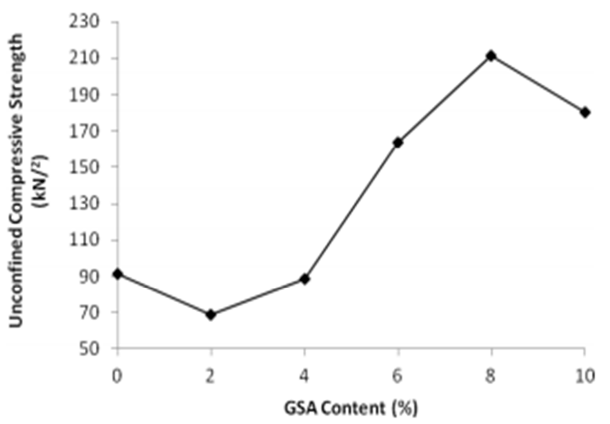

Figure 2. *Variation of UCS with GSA content.*

2.2.4. Stabilization of Black Cotton Soil Using Bagasse Ash

Jayatheertha [14] Conducted a study and established that the Bagasse ash waste is used in enhancing engineering properties like CBR value of the soil while demolished waste concrete is more effective than bagasse ash in the improvement of index properties such as liquid limit, plastic limit of the black cotton soil. The CBR value increased from 1.28% to 12.34% for soaked condition, and for unsoaked condition CBR value rises from 2.38% to 16.23%.

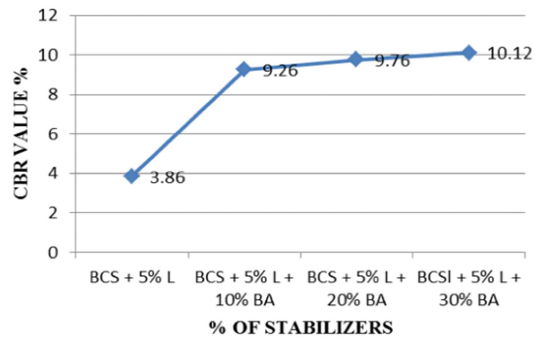

Figure 3. *Variation in CBR with lime and bagasse ash in unsoaked condition.*

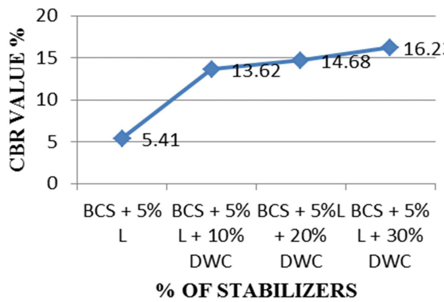

Figure 4. *Variation in CBR with lime and demolished waste concrete in unsoaked condition.*

Amit [4] Studied some laboratory trials on black cotton soil using Bagasse Ash as a partial substitute (3.2 percent, 6.4 percent, 9.6 percent and 12.8 percent). This research shows 6 percent substitution of Bagasse Ash improved the characteristics of black cotton soil without using any chemicals or cementing materials. The Plasticity Index of Bagasse Ash treated soil was found to be reduced from 24.00 percent to 17.40 percent. The density of black cotton soils increased significantly from 1.57 to 1.78 g/cc after adding 6% bagasse ash. However, OMC falls from 17.20% to 15.00%. Density falls as more Bagasse Ash is added, whereas OMC rises. At 6% bagasse ash concentration, UCS values improved from 93 kN/m^2 to 429 kN/m^2. UCS values decline as more Bagasse ash is added. When compared to the other dosages, the rise in California bearing ratio value at a dosage of 6% had a stronger effect. A decrease in settling is indicated by an increase in the California bearing ratio. Because of the addition of 6% waste Bagasse Ash, CBR values increase significantly from 1.16% to 6.8%. CBR values start to decline as more Bagasse ash is added.

Gabriel [12] Looked at how bagasse fiber could be used to improve the engineering features of expansive soils for road pavement systems. Preliminary examinations classified the clay soils as A – 7 – 6 on the AASHTO Classification System, and the soils are dark grey under all conditions, with 73.85 percent, 67.38 percent, 6.35 percent, 82.35 percent, and 71.55 percent passing BS sieves #200. Clay soils' plastic index qualities decreased, according to comparative data. Due to the introduction of bagasse fiber in the compaction test, MDD values fell but OMC values increased. The results showed that increasing the fibre percentages to soil matching ratio resulted in an increase in UCS. With an increase in bagasse fibre percentages, CBR values increased to a peak ratio of 0.75 percent to soil ratio, according to the data. The results demonstrated that costaceae lacerus bagasse fibre (CLBF) might be used as an additive in the treatment of black cotton soils. The swelling potential of treated soil was reduced by up to 0.75 percent when bagasse fibre was added.

2.2.5. Stabilization of Black Cotton Soil Using Bagasse Ash and Other Additives

Kiran et al [22] conducted laboratory experiment with varied amounts of bagasse ash of percentages 4, 8, and 12 and additive mix proportions. In addition, a study was conducted on the utilization of bagasse ash waste to stabilize pavement materials for construction. for black cotton soil, the mix proportion of bagasse ash with various percentages of lime resulted in an improved values of CBR and Unconfined compression strength. However, when the amount of lime in the mixture increased, the density values fell. After that, an icrerease in CBR was observed in the blend ffrom 2.12 to about 4.57 at 4% bagasse ash addition and 4% lime content, so also the unconfined compression strength, from 84.92 kN/m^2 to 153.05 kN/m^2 2 with the addition of 4% bagasse ash and 2% lime. The combination of 2% to 4% lime and 4% to 8% bagasse produce much higher strength.

2.2.6. Stabilization of Black Cotton Soil Using Reclaimed Asphalt Pavement

Mustapha [25] Studied the effect of Reclaimed Asphalt Pavement (RAP) to stabilize Black Cotton Soil (BCS) gathered from Numan in Nigeria's north-eastern area and black cotton soil from a collapsed road surface along the Minna-Bida road in Niger state. The BCS was replaced with RAP at a rate of 0%, 10%, 20%, 30%, and 100% by weight of the soil. Quartz, microcline, albite, and kaolinite were found in abundance in the BCS, whereas quartz, albite, orthoclase, phylogopite, and actinolite were found in abundance in the RAP. The mixtures' maximum dry density (MDD) improved from 1890kg/m^3 at zero percent Reclaimed Asphalt Pavement content to a maximum of 2036kg/m3 at 30 percent RAP, then decreased to 1925kg/m3 at 100 percent RAP. Scanning Electron Microscopy demonstrated less cracks in mixtures containing 20 and 30 percent RAP, instead revealing an interlocking of particles of various sizes in a dense state. Unconfined Compressive Strength (UCS) rose by 58.6% from 392kN/m2 at 0 percent RAP content to 947kN/m2 at 30 percent RAP content. After that, at 100 percent RAP content, the results dropped to 17.5kN/m2. The modulus of elasticity increased by 75.5 percent from 10.4 MPa at 0 percent RAP to 42.5 MPa at 30 percent RAP. After that, the readings dropped to 2.9MPa at 100 percent RAP content. The combinations' swelling potential ranged from medium at 0% RAP content to low at 30% RAP level.

2.2.7. Stabilization of Black Cotton Soil Using Fly Ash

Gourav [13] Investigated the effect of fly ash on black cotton soils. It was used to stabilize extremely flexible clay in this investigation. Geotechnical parameters of the soil were assessed. Laboratory experiment including Atterberg limits, California bearing ratio, and unconfined compressive strength (UCS) were conducted to achieve the objectives of the study. Various quantities of fly ash were used to stabilize the soil, raging between 0 and 30%. The UCS of black cotton soil–fly ash mixes is found to be highest at 20% fly ash concentration and thereafter falls as fly ash percentage increases. However, when fly ash was blended with soil, the CBR value produced was lower than when the soil was virgin. Furthermore, CBR with two-thirds fly ash soil and one-third subbase yielded superior results. At 20% fly ash concentration, the highest CBR value was determined to be 5.03 percent. These findings are noteworthy because they show that fly ash may be used as a subgrade material in real-world settings since the subgrade layer is covered by a subbase course. The CBR value is used to determine the thickness of flexible pavements. The finding established that fly ash can used to stabilized deficient soil for pavement and foundation construction.

John [10] Reported that, Black cotton soil soiln ca be stabilized by the use of lime and block powder. Although there is improvement in the geotechnical features of the soil under study, the increment was not up to the requirement of subbase material. Hence Block powder and lime-blended black cotton soil mixture can be used as a sub base material in flexible pavements in rural areas where block powder is readily available in large quantities, as well as in areas where good quality material is scarce.

2.2.8. Stabilization of Black Cotton Soil Using Plastic Waste

Mehruddin [37] Carried out an investigation on the potential use of plastic trash for soil enhancement using plastic strips. By varying the plastic waste content from 0% to 8%, standard proctor tests, CBR testing, and unconfined compression tests were done. The best amount of plastic garbage to add to improve each of the three experiments was studied and found to be 2% by weight of black cotton soil. The OMC values first fall with 2 percent plastic waste replacement, according to the results of a standard proctor test. However, once OMC surpassed 2% plastic, it increased until it reached 5% plastic and then declined. At 2% plastic and 4% plastic, the OMC value was practically same. The maximum MDD value of 1.47 g/cc was recorded with 2 percent plastic, which also had the highest MDD value of all the experiments done. As a result, it can be stated that the optimum plastic content for best compaction using the plastic strips used in this investigation is 2%. The CBR value increased from 14 percent at 0% to 26 percent at 2% plastic. The CBR value was shown to decline whenever the plastic content exceeded 2%. It's possible that the soil's strength improves as a result of the plastic strip reinforcement. As a result, it is reasonable to deduce that the optimum plastic content for enhancing CBR is also 2%. The compressive strength of the soil was found to be greatest at 2% plastic in an unconfined compression test with varied percentages of plastic strips. The unconfined compressive strength was 2.36 kg/cm2 without any plastic replacement, and at 2% plastic replacement, the unconfined compressive strength nearly doubled to 4.96 kg/cm2. As a result of this research, it is possible to conclude that plastic trash from stationery products can be used efficiently to increase the strength properties of black cotton soil.

2.3. Stabilization of Black Cotton Soil Using Non-chemical Admixtures

2.3.1. Stabilization of Black Cotton Soil Using E-waste

KPrabin [23] focuses on soil stabilization utilizing strong trash (E-waste). Commercial wastes may be used successfully as a substitute material in soil stabilization, according to the findings of the study. It also shown that each company trash had its unique properties and altered the soil's index and engineering homes. Stabilized soil is used as a green material in the construction of structures as a result of these house improvements.

Onkar [28] Experimented a program to evaluate the influence of E-waste at various dosages on black cotton soil. Various concentrations of E-waste were mixed with the soil ranging from 2%, 5%, to 8%. Physical and strength performance tests, such as Atterberg's limit, specific gravity, compaction test, unconfined compressive test, California bearing ratio (CBR), and direct shear test, were used to assess the performance of E-waste stabilized soil. These tests were carried out in order to assess the progress made in the soil's strength qualities According to the findings, the specimen's unconfined compressive strength rose to a value of 2.63 kN/m^2 at an optimum dosage of 5%. There was an increase in the angle of friction (Φ) after performing the direct shear test. Friction angle rose as the percentage of E-waste grew. Because bearing capacity is influenced by C and, it was also discovered that the bearing capacity has improved. As the holes in the soil were filled with E-waste, MDD increased by 2% and OMC reduced by 5%, resulting in dense soil. For an E-waste dosage of 8%, MDD gradually dropped. This shows that 5% dosage of E-waste can be considered as the optimum dosage percentage.

Mangesh [24] Used Physical and strength performance tests, such as Atterberg's limit, specific gravity, compaction test, unconfined compressive test, California bearing ratio (CBR), and direct shear test to assess the performance of E-waste stabilized soil. These tests were carried out to see whether the soil's strength qualities had improved. According to the findings, the specimen's unconfined compressive strength rose by an average of 2.41 kN/m2 at a fixed dosage of E-waste. There was an improvement in the angle of friction (Φ) after performing the direct shear test. grew in tandem with the percentage of E-waste generated. The Specific gravity and liquid limit increased with the addition of 5% E-waste, but fell with the addition of 8% E-waste, while the plastic limit climbed abruptly with the addition of 5% E-waste. It has been discovered that when the amount of E-waste increases, the soil's free swell index values fall. It can said that E-waste can be considered as a potential stabilizer for the said soil.

2.3.2. Stabilization of Black Cotton Soil Using Ionic Soil Stabilizer 2500

Hashim [15] assessed "Ionic Soil Stabilizer 2500" effects on black cotton soil in North-East Nigeria, samples were collected along the Dikwa–Gamboru Ngala route. The black cotton soil appeared to be deficient because more than 60% of the soil passed through 0.0075mm diameter sieve discovered from particle distribution test. The main constituents of the Ionic Soil Stabilizer are organic bi-sulphate acid and Sulphur. The Ionic Soil Stabilizer doses of 0, 1, 2, and 3mls were mixed with 6kg weight of black cotton soil for laboratory investigations. According to the results of the pH tests, due to the presence of acids in the stabilizer, acidity of the samples rises as the Ionic Soil Stabilizer increased. There was a significant decrease in plasticity, and the electrical conductivity also rises. California Bearing Ratio test was carried out utilizing the British light compaction technique in line with energy levels. As a result, the CBR values rose slightly, but still fell short of the criteria for soil-cement stabilization in pavement foundation materials. The Ionic Soil stabilizer from the experiment has not generated a satisfactory result from which conclusions can be drawn about its usefulness in bringing black cotton soil characteristics up to road base criteria.

2.3.3. Stabilization of Black Cotton Soil Using Steel Mill Scale

Ogundalu [2] determined Black cotton soil stabilizing potentials when treaded using steel mill, tropical Black Cotton clay soils were mixed with Steel Mill Scale at 0 percent, 5 percent, 10 percent, 15 percent, 20 percent, and 30 percent Steel Mill Scale content (by dry weight of soil). Steel mill scale increased the soil's Maximum Dry Density (MDD) by about 19% and decreased the Optimum Moisture Content (OMC) by about 28%. Soaked CBR increased as Steel Mill Scale content grew, whereas Un-Soaked CBR fell as Steel Mill Scale content increased. Steel mill scale increased the unsoaked CBR by around 19% while lowering the soaked CBR by about 75%. With the use of Steel Mill Scale, the risk for swelling is reduced by around 60%. At 5% Steel Mill Scale content, Steel Mill Scale increased the unconfined compressive strength of black cotton soils by nearly 53%. The findings suggest that using Steel Mill Scale to fortify Black cotton soils has potential.

3. Conclusion

Various researches showed that Black cotton soil can be stabilized to achieve better engineering properties rather than just disregarding the type of soil for its undesirable expansive features when exposed to variation of moisture condition. Stabilizers such as lime, cement, E-waste, reclaimed asphalt pavement, and steel mill ore has shown an excellent improvement when used to stabilized the soil while on the other hand stabilizers such as groundnut ash, bagasse ash and plantain peel powder demonstrated unsatisfactory improvement when used standalone. It can be recommended to supplement these types of weak stabilizers with some rather cementitious materials so as to achieve a strong and durable soil for foundation or sub-grade material.

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