A Literature Review of Soil Stabilization Methods and Materials

Komal K Dave, Ketan J Dave
Assistant Professor, Civil Engineering Department, KSET, KPGU, Vadodara, Gujarat, India, 391240
Quality Manager, L& T Construction

Abstract: When the soil on the site is inappropriate, it can be improved using the soil stabilization method. Numerous engineering properties, including permeability, shear strength, permeability, liquid and plastic limits, unconfined compressive strength (UCS), California Baring Ratio (CBR), maximum dry density (MDD), and optimal moisture content (OMC), are improved by stabilizing the soil. Chemical stabilization and mechanical stabilization are the two categories into which all soil stabilization techniques fall. Chemical stabilization is the process of altering the chemical properties of soil by adding different admixtures, while mechanical stabilization is the process of stabilizing the soil by changing its composition or gradation. Fly ash, lime bitumen, copper slag, sawdust ash, quarry dust, stone dust, steel slag and brick, plastic waste, bamboo charcoal powder (BCP) cement, and elephant dung strips are just a few of the materials used as soil stabilizers.

Keywords: Geotechnical engineering, Soil stabilizer, moisture content (OMC), maximum dry density (MDD), Unconfined compressive strength (UCS), and California baring ratio (CBR), Plastic Waste Material, Fly ash, lime.

1. Introduction

The unconsolidated deposits or mixture of minerals, organic matter, and fragments that cover a significant portion of the earth's crust are known as soil. As a result, different kinds of soil exist and differ globally, and as a result, so do the characteristics of soil. India has expansive soil on almost 20% of its land. We are aware that when the soil is wet, its shear strength is lost. Therefore, soil needs to be strong enough to support any civil engineering structure. Therefore, soil stabilization techniques are employed when it is necessary to enhance the soil's engineering qualities and suitability. The process of altering one or more soil characteristics with a soil stabilizer in order to enhance soil performance is known as soil stabilization. As a result, stabilization is employed in many engineering projects. The most prevalent use of soil stabilization is in the building of roads and pavements, where the primary goal is to improve the soil's strength or suitability. There are two key techniques for stabilizing soil: mechanical stabilization and chemical stabilization. In some cases, mechanical stabilization is not feasible or cost-effective, and it is even inappropriate to substitute desirable soil for undesirable soil.

2. Review of literature

Ashish kumar phatak et al (2014) A soil scientist has studied the effect of ground-breaking slag (GGBS) on soil and concluded that the maximum dry density increases and optimum moisture contain is decreased with addition of GGBS to soil. Maximum dry density is highest at 25% added to soil and maximum moisture content is lowest at 0%.

Oormila T. R. et al. (2014) 20% of GGBS gives the maximum increases in CBR value compared with all other combinations of fly ash and granulated blast furnance slag. The sample is was tested is collected from palur, Tamil nadu and then differentpercentages offly ash (5%, 10%, 15% and 20%) and GGBS were added to compare the strengthresults with its original strength.

Kayal Rajakumaran (2015) studied the effect of steel slag and fly ash on expansive soil. He added the different percentage of steel slag and fly ash in expansive soil. Then the performance of modified soil is check by different tests such as permeability test, compaction test and unconfined compressive test. Based on these tests the percentage of steel slag and fly ash is calculated.

Prof. Mohammed (2015) had investigated about the improvement in soil properties of Expansive soil by using copperslag. The soil properties like Grain size analysis, liquid limit, plastic limit, plasticity index, compaction test, direct shear test andCBR were determined. He concluded that copper slag 40% and Black cotton soil 60% was optimum and it showed the increase invalue of specific gravity and CBR. He finally concluded that such soil can be effectively used in road embankment sub base andsub grade.

Kavak et al (2016) studied the effect of ground granulated blastfurnance slag and lime on Ankara clay soil. When his evaluated the result of experiment then based on these result he conclude that unconfined compressive strength (UCS) and California bearing ratio (CBR) increases. The increase in value is 46 times in CBR values for Ankara clay compared to natural case in 28days cured samples.

Dayalan J (2016) at the University of British Columbia in Canada.The optimum percentage of fly ash is 15% and that of GGBS is 20% for positive results, according to a study by Ground granulated blast furnance slag and fly ash have been used as well as ground granulated granite ash for stabilizing soil.

Prof. Summaya (2016) had studied about the soil stabilization using tile waste. In this paper, tests were conducted on UCS, CBR, liquid limit, plastic limit, compaction test and shrinkage limit. She concluded that there was reduction in value of liquid limit, plastic limit and OMC and increase in the value of shrinkage limit, MDD, UCS, CBR on addition of tile waste up to30%.

Prof. Paliwal (2016) had experimentally studied about the stabilization of sub grade soil by using foundry sand waste. In this paper he tested various properties like liquid limit, plastic limit, plasticity index, Standard proctor test, CBR and Direct shear test. He concluded that the CBR value and angle of internal friction of soil was improved with addition of 20% found dry dust. He also concluded that OMC shows a lower value for 10% replacement of foundry waste.

Prof. Ravi (2016) had studied about the characteristics of clay soil by using copper slag stabilization. In this paper, he tested the CBR and Max density, OMD relationship. He observed higher CBR values in 30% replacement of copper slag and this was also served as good conformity for the flexible pavement with simultaneous reduction in the sub base course thickness. He finally concluded that the addition of 30% copper slag with 70% BC soil was the suitable stabilization ratio which increased all characteristics of sub grade requirements.

Prof. Ramesh babu (2017) had investigated about the behaviour of black cotton soil with addition of copper slag and steel slag. The soil samples are tested by compaction test, unconfined compression test and CBR. It is concluded that CBR, optimum moisture content, maximum dry density and shear strength are increased when the soil is added with 20% of copper slag and steel slag.

Prof. Ranjendra kumar (2017) had studied about the Black cotton soil blended with copper slag and fly-ash which are added in different percentages. The soil properties like liquid limit, plastic limit, plasticity index, free swell, compaction test and CBR (unsoaked) were determined. The results indicated that the dry density, CBR values were improved and swelling was reduced due to addition of copper slag 30% and fly ash 10% (% by weight of soil) in the soil.

Salim et al., 2018 utilized arbitrarily shredded plastic waste-based ethylene into different aspect ratio for strengthening the clayey soil collected from Baghdad. Three percent of plastics waste were selected (1 %, 2%, 4 %) by the weight of the dry soil and compared with soil without plastic. The measured soil properties were specific gravity, California bearing ratio, unconfined compressive strength, and Atterberg limits. The outcomes demonstrated that the addition of the plastic waste significantly effect on the modified clayey soil. The specific gravity decreases as percentage of waste plastic increases. The decrement of the specific gravity for 1%, 2%, and 4% plastic waste were approximately 6%, 11%, and 15 % when compared with soil without plastic, correspondingly. The California bearing ratio increase as percentage of waste plastic increases. The increment of the California bearing ratio for 1%, 2%, and 4% plastic waste were approximately 55 %, 105 %, and 200 % when compared with soil without plastic, correspondingly. The unconfined compressive strength increases as percentage of waste plastic increases. The increment of the unconfined compressive strength for 1%, 2%, and 4% plastic waste were approximately 42 %, 83 %, and 180 % when compared with soil without plastic, correspondingly. The liquid limit decrease as percentage of waste plastic increases. While, plastic limit increase as percentage of waste plastic increases. The decrement of the liquid limit was 2%, 11 %, and 15 %. While, the increment of plastic 4%, 8 %, and 16 for 1%, 2%, and 4% plastic waste when compared with related value of soil without plastic.

Irshayyid and Fattah, 2019 investigated the behavior of expansive soil (80% clay + 20 % sand) with addition of waste plastic based of high-density polyethylene at fractions (4, 8, and 12) wt. % of dry soil. The results exhibited that the waste plastic fibers considerably enhanced the properties of expansive soil. The liquid limit values reduced as the plastic percent increase, while the plastic limit increased. The reduction percent of the liquid limit ranged from (8.5 -11.5) %, and the rising percent of plastic limit ranged from (26.4 - 81.2) %. Also, the unconfined compressive strength increases as the percent of waste plastic increase. the growing percent ranged about (13- 100) %.

Al-Taie et al. 2019 implemented experimental study on the influence the insertion of depolymerized waste polyethylene terephthalate on the sandy soil. The waste plastic was shredded to (3×3) mm chips, then depolymerized to fine powder, and finally, added to sandy soil at various percent (0.5, 1.0, 1.5, and 2) wt.%. The test results exhibited that the properties of the sandy soil improved by the addition of depolymerized waste plastic. The improvement of the angle of internal friction reached to about 30 % for addition percent 2 % of plastic percent when compared with sandy soil without plastic. Also, the soil compression of plastic treated soil enhanced considerably.

Al-Neami et al. 2020 inspected the opportunity of utilizing polypropylene waste fibers to improve the cohesive clayey soil. Three different length of plastic fibers (6, 12, and 18) mm were separately added to soil at different percentage (0.25, 0.5, and 0.75 %) by dry weight of soil. The experimental results exhibited that the reinforcing of soil by polypropylene fibers considerably improved the unconfined compressive strength and shear strength, also, the length of plastic fibers has an appreciable effect. The increase in cohesion value as shear parameter reached around 40 %, 70 %, and 100% for 6, 12, 18 mm fibers length related to native soil, respectively. The increase in the unconfined compressive strength parameter reached around 32 %, 47%, and 64 % for 6, 12, 18 mm fibers length related to native soil, respectively.

Kadhum and Aljumaili, 2020 studied the application of plastic waste on the properties of subbase soil containing powder of ceramic waste. Domestic plastic waste was shredded to strips with dimensions (12 ×8) mm, and then added to subbase soil containing optimum ceramic waste at various fractions ranged from (0.25 - 1.0) wt. % of dry soil. They stated that the California bearing ratio value increased with increasing the percent of plastic waste. The maximum increment reached about 18 % for 1 % plastic waste strips compared with soil without plastic.

Fadhil et al., 2021 conducted experimental work involved a series of unconfined compression tests on a sand-clay soil (60 % sand + 40 % clay) with / without adding waste plastic. The parameters of the study involved shape (plain and corrugated), length (5, 10, and 15 mm), width (1, 2, and 3) mm, and present of waste plastic addition (0.25, 0.5, 0.75, and 1.0) %. In general, the utilization of the waste plastic improved the unconfined compressive strength. The maximum increment in the unconfined compression strength obtained for (1×15) mm fibers at 1% plastic addition was about 181 % and 270 % for plain and corrugated, respectively.

Jaber et al., 2021evaluated the outcome of addition plastic waste on the strength properties of subbase. Five fractions of recycled polyethylene terephthalate plastic granule with cylindrical shape, 2.5 diameter and 4 mm height, the fractions ranged 2.5 to 12.5 % by volume (equivalent for near 1 to 4 % by weight). The results specified that the insertion of plastic waste granule significantly altered the performance of subbase. The increasing present in California bearing ratio for waste plastic granule was ranged from (6 - 36) %. They recommend 10 % of addition waste plastic granule.

Hameed et al., 2021 directed an experimental study on the influence of application of the waste plastic fibers on the performance of lime stabilized sandy soil. plastic fibers originated from low density polyethylene waste were utilized with different length (5, 10, and 20) mm, at various percent of addition (1, 2, and 3) % wt. of the soil. The results demonstrated that addition 10 cm length waste plastic fibers at 3% content produced a reduction in the surface deflection around 21 % and an increase in the dynamic modules of about 28 % as compared to soil without plastic.

A S Abdul Rahman et al.,2022 research article aimed to evaluate the impact of utilizing plastic waste as an additive in the soil stabilization process. The following hypotheses were developed based on the findings and reviews. The most imperative findings of this study were that the ideal treatment level of plastic waste in soil that fulfils the study's goals and objectives was 2% where the amount of plastic waste was anticipated to strengthen the soil strength.

Kennedy V. Rodriguez et al.,2023 an experimental Study of plastic strips as soil stabilizer to clayey soil in subgrades is increased 17 % CBR strength than that of the untreated soil sample, it is achieved by adding optimum plastic content of 1% in the soil and further increase will only get lower CBR value. It can be concluded that using waste plastic strips as a soil stabilizer can be a way to reduce the overwhelming increase to the waste pollution in the country by using it as an agent to soil stabilization. Based on the comparative analysis of plastic waste strips among other usual admixtures, it is more economical and environmentally friendly to use.

3. Material and Methods

3.1. Soil stabilizers used for soil stabilization

3.1.1. Fly ash

Fly ash is a byproduct which is generated from burning coal in electric power plant and steam creating plant. Fly ash consist silicon, aluminium, iron oxides and unoxidizedcarbon. By ignition of anthracite and bituminous type of coal which contains less than 20% calcium oxide gives class F fly ash and class C fly ash. Erdal Cokca (2001) conclude that when soil specimens are treated with 25% of class C fly ash then swelling pressure decreased by 75% after 7-day curing, and 79% after38 days curing. Ji-ru and Xing (2002), Zha et al. (2008) and Bose (2012) observed positive result when he studied the effects of lime and class F fly ash (FFA) added to expansive soil. Some limitations of fly ash stabilization is summarized below

a. Soil-fly ash mixture is free from sulphur content because it affects the long term strength and durability.

b. Moisture content in soil which has to stabilize is less.

3.1.2 Lime

Lime enhances the characteristics of soil; it can aid in soil stabilization. It needs enough heat, at least 40 degrees Fahrenheit. By delaying the start of the construction process, increases the amount of heat that is necessary for the reaction. with dirt. Typically, lime reacts with somewhat fine-grained materials. soil with fine grains. The kind of lime depends on the soil. and the quantity is determined by whether the soil has been amended. stabilized. Following are the types of limes generally used.

Hydrated high calcium lime

Monohydrated dolomite lime

Calcite quick lime

Dolomite lime

Lime can be used alone or combination with cement, bitumen, or fly ash. It effects on the soil by cation exchange or pozzolanic action due to cementing effect. Lime soil mixture gives sufficient durability to resist the structure make sure those heavy vehicles are not allowed within 14 days. Amount can be calculated by using CBR test or unconfined compressive strength. CBR test conducted with raw soil using 4, 5 and 6% lime. For coarse grained soil 2 to 8% and for plastic soil 5 to 10% of lime is required. Fly ash is mix with lime about 8 to 20% of soil weight. Quantity of lime can be calculated by % by weight not by volume for that you must know density of soil by doing compaction testing. Stabilization should be 6 inches for marginal soil, 8 to 9 inches for poorer and 10 to 12 inches for very worst soil. Determination of lime for project you must consider project length, variable alignment, rock, new or old construction. Lime moderately improves engineering property, workability, impermeability and load bearing capacity of soil. It is more suitable in high temperature area as compared to low temperature area and suitable for soils like clay, silty clay, and clayey gravel and not for granular and sandy soil.

3.1.3 Cement

Soil cement stabilization is hydration of cement particles that can interlock with one another and gives high compressive strength. Cement acts as a binding agent. For effective stabilization size distribution is necessary it gives high strength bond between cement and soil. The quantity required is depending on the type of soil. Very poor soil is uneconomical for stabilization. Cement stabilization has some advantages over other stabilization.

3.1.4 Slag

It is a readily accessible admixture that is produced as a byproduct during the production of iron in blast furnaces or as a byproduct of other metals.

3.1.5 Bitumen

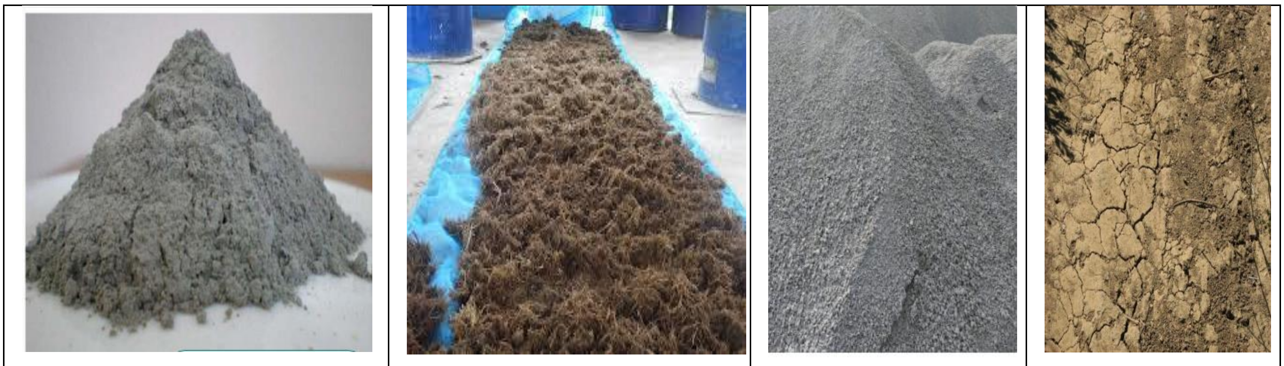
The bituminous compounds used to stabilize soil are asphalts and tars. Bitumen is incorporated into soil during the bituminous soil stabilization procedure to improve the soil's cohesiveness and load bearing capability. Bitumen addition seals soil pore openings, reducing soil permeability. The kinds of bitumen that are used for bitumen soil stabilization depend on the soil types that need to be stabilized, the building technique, and the weather. The parameters that seem to be most crucial to regulate in the creation of pavement employing bituminous stabilization include surface moisture content, asphalt viscosity, asphalt content, uniformity of mixing, compaction, aeration, compaction, and curing.

3.1.6 *Bamboo Charcoal Powder*

The bamboo charcoal powder was the material used as an additive for soil stabilization. Bamboo charcoal powder ware took from the manual combustion process, the steps for preparing bamboo charcoal powder:
1. The bamboo that has been provided ware dried until the color of the bamboo turns yellow.
2. The bamboo was burned for 10 days in the kiln.
3. After that, the bamboo cooling process was carried out for 10-14 days.
4. Next, the finished bamboo charcoal was pounded using a rubber mallet and sieved with a sieve shaker

3.1.7 Extraction of bio-strips from elephant dung

Elephant dung was mixed with a pool of water and then mixed thoroughly. Bio strips are separated by pulling with hand and then it is dried for 24 hours. The thickness of the bio strips thus obtained varied from 0.2 to 0.4mm and these bio strips were cut into a length of around 3 to 5cm. The high lignin content in elephant dung contributes to higher flexibility, durability and slow biodegradation compared to other natural materials. When dried, these strips act like fibres and thus prove to be an effective material which can be used to stabilize soil.



(a) (b) (c) (d)

Figure 1. Different Materials used for soil stabilization (a) Fly ash (b) Elephant dung (c) Slag (d) Expansive soil

3.1.8 Plastic Waste

The polyethene terephthalate (PET) plastic bottle was used and shredded using a shredder machine in this investigation to achieve the consistent size of the plastic shreds. Plastic bottles served as reinforcement in the varied proportions of 0%, 1%, and 2%, which symbolize the plastic waste's mass to the soil sample's mass.

Figure 2. Preparation of plastic sample

3.2 Methods

3.2.1. Soil

The sample of this research from Reklamasi Village, Air Jangkang Merawang, Bangka is soft soil. A series of an experimental test of soil was conducted in the laboratory. Laboratorium tests were done on the sample according to Indonesia National Standards (SNI). Based on the USCS method of soil classification, the sample of this research is classified in Inorganic Clays with low plasticity (CL). Index properties of soil as given in Table 1.

Table 1 Index Properties of Soil

Specific Gravity (GS) (gm/cm^3)	Natural Moisture Content (W) (%)	Liquid Limit (LL) (%)	Plastic Limit (WL) (%)	Maximum Dry Density(MDD) (gm/cm^3)	Optimum Moisture content(OMC) (gm/cm^3)
2.63	31.83	35.68	20.46	1.76	18.3

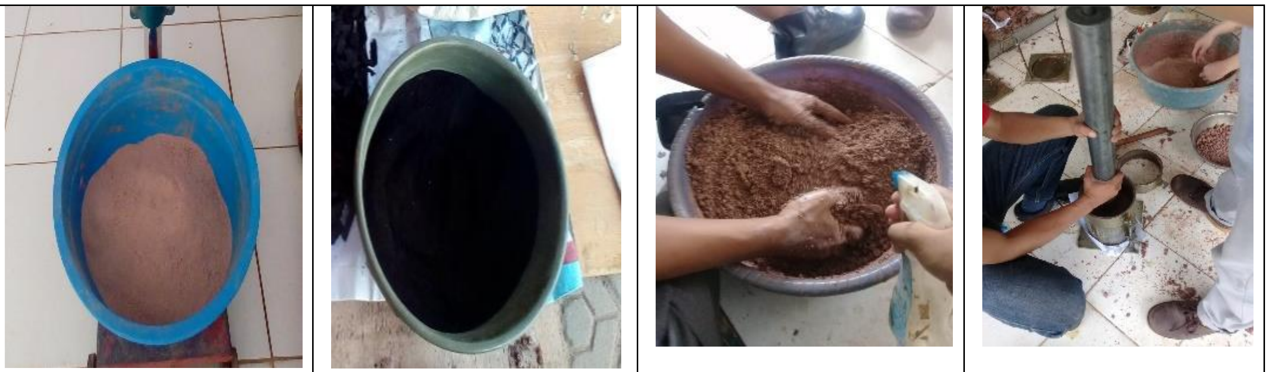
3.2.2. *Bamboo Charcoal Powder*

In this research, the bamboo charcoal powder was the material used as an additive for soil stabilization. Bamboo charcoal powder ware took from the manual combustion process, the steps for preparing bamboo charcoal powder:
1. The bamboo that has been provided ware dried until the color of the bamboo turns yellow.
2. The bamboo was burned for 10 days in the kiln.
3. After that, the bamboo cooling process was carried out for 10-14 days.
4. Next, the finished bamboo charcoal was pounded using a rubber mallet and sieved with a sieve shaker

Original clay was mixed with bamboo charcoal powder, it uses water with optimum moisture content based on soil compaction results testing, as given in table 1. Bamboo charcoal powder mixed into original clay with varying levels of 5%, 10%, and 15% of the dry weight of the soil. The mixture variation of this research is given in table 2. The process of mixing material is shown in figure 3. Furthermore, a California Bearing Ratio (CBR) test ware carried out on the original clays and stabilized clays.

Table 2. Mixture Variation

No	Mixture Variation.	Number of Sample
1	Clay	6
2	Clay + 5% Bamboo Charcoal Powder	6
3	Clay + 10% Bamboo Charcoal Powder	6
4	Clay + 15% Bamboo Charcoal Powder	6



(a) (b) (c) (d)

Figure 3. Samples Preparation For CBR Testing (a) Clay (b) Bamboo Charcoal (c) Mixing (d) Compaction

3.2.3 *California Bearing Ratio*

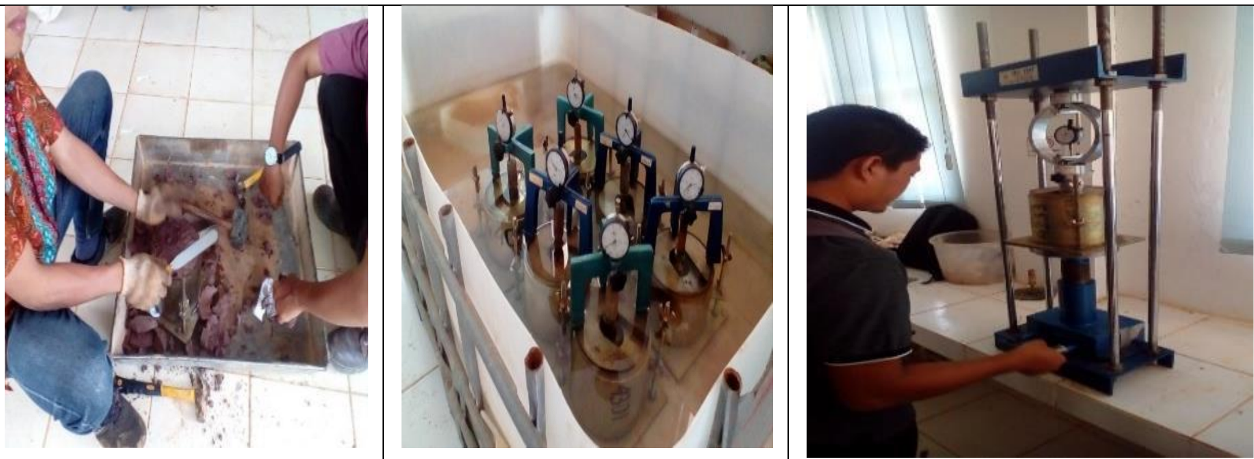
California Bearing Ratio (CBR) is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material.

CBR = (PT/PS) X 100 (1)

PT = Corrected test load corresponding to the chosen penetration from the load penetration curve.

PS = Standard load for the same penetration

CBR testing was carried out on the original clay and clay that had been stabilized with bamboo charcoal powder. In this study, CBR testing was carried out under soaked conditions using guidelines based on SNI 1744:2012 carried out with 3 (three) types of blow namely 10, 30, and 65 blow. The CBR soaked testing is carried out after the compaction test is completed. After being compacted, the sample was soaked for 4 (four) days and the value of its development was observed only after which the CBR test was carried out. The results of the test are then displayed in the figures. Then the results of the test were compared with the respective percentages of 5%, 10%, and 15% of the addition of bamboo charcoal powder. The process of CBR Testing is shown in figure3



(a) (b) (c)

Figure 4. The Process of CBR Test (a) Mixing the Sample (b) Soaking the Sample (c) CBR Test

3.2.4 *Standard Proctor Test*

The researchers used the following materials and equipment, Cylindrical Metal Mold, Rammer, Weighing Balance, Thermostatically Controlled Oven, Steel Straight Edge, Pan, Sieve # 4, Sand Scoop, Mixing Tools (trowel) and sand. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content, the soil is first oven dried and pulverized. The oven dried soil must undergo sieve through using #4 sieve, reject the coarser material. The soil sample was separated into 5 samples. The water substance of each example is balanced by including water. The first compaction has no water, the second compaction was added 150cc of water as well as 3rd, 4th and 5th compaction. For each set of compactions, the soil is placed in the Proctor compaction mold in three unique layers where each layer gets 25 blows of the standard mallet. Before putting each new layer, the outside of the past layers is scratched so as to guarantee a uniform appropriation of the compaction impacts. At the finish of the test, in the wake of expelling and drying of the example, the dry thickness and the water substance of the example is resolved for each Proctor compaction test. In light of the entire arrangement of results, a bend is plotted for the dry unit weight (or thickness) as a component of the water content. From this bend, the ideal water substance to arrive at the most extreme dry thickness can be acquired. determines the MDD (Maximum Dry Density) and OMC (Optimum Moisture Content) Calculated.

Conclusion

From the above literature review we can conclude the following things:

1. The conclusion of this study is based on the findings of the soil test laboratory, which showed that adding bamboo charcoal powder to clay may raise the California Bearing Ratio value when the powder concentration is increased to 15%. It is evident that adding bamboo charcoal powder can increase the soil's bearing capacity.
2. According to the study, elephant dung strips can be utilized to enhance the characteristics of soil. Elephant dung strips may considerably boost the strength of soil when used up to 4% of its weight. Elephant dung strips alone may not be durable enough to be used as soil because it is a natural organic substance. However, this is capable of withstanding the heavier loads that are expected during the early phases of construction, preventing significant damage and consolidation settlements. In order to eliminate any lingering concerns about durability, these elephant dung strips may be utilized in place of nearly half of the lime required for stabilization, providing higher strength attributes at a lower cost. Elephant dung strips may replace about 75% of the lime, adding strength.

3. The waste plastic materials are environmental ecofriendly resources utilized as a soil stabilizer to diminish the harmful impacts of these waste materials. A review of these waste plastic materials that conducted by Iraqi researchers was displayed and discussed in this article. It was revealed that:

a. Outcomes of numerous local researchers offer an encouraging implication to the opportunity for application the recycled waste plastic for stabilizing or reinforcing of different soil. These employments dispose the waste plastic and reduce using of virgin materials.

b. The insertion of the waste plastic in the soil considerably improves the desired properties of treated soil. The addition of the waste plastic in treated soil ranged from (0.5 - 4.0) wt. % of dry soil. Also, the shape and measurement of added plastic marginally effect on improvement of soil.

c. In general, the compaction properties for treated soil decreased as fraction of waste plastic in soil increased. The reduction in maximum dry density and optimum moisture content for treated soil extended up to 15% and 20 % compared with relative untreated soil.

d. California bearing ratio for the treated soil increased as the percentage of the plastic in the soil increased as well. The rising percentage in the value of California bearing ratio touched about 80% in comparison to the untreated soil.

e. The addition of the waste plastic to soil greatly effects on Atterberg limits. The addition of plastic decreases the plasticity index and liquid limit, however the plastic limit of soil increased. The effect on the Atterberg limits stretched up to 70 %, 81%, and 21% for plasticity index, plastic limit, and liquid limit respectively as compared with natural soil.

f. Unconfined compressive strength and shear strength of the waste plastic treated soil significantly improved when waste plastic added to the soil. The improvement in unconfined compressive strength and shear strength up to 270% and 240%, respectively.

4. Because it simultaneously provided two benefits—improving the soil's characteristics and lowering the amount of industrial waste discharged on arable land—soil stabilization had become the most necessary one. The benefit of dirt
Around the world, stabilization utilizing industrial waste has become attractive. Twenty reviews of soil stabilization articles Products made from industrial waste were addressed. It was determined from the review that industrial trash can be utilized as Substitute substance for soil stabilization. It also made it quite evident that each type of industrial waste displayed its unique the soil's characteristics, modified index, and engineering features. Due of these altered features; the dirt that has been stabilized is a useful building material.

5. From this above review paper, it can be concluded that the several methods are implemented for modification of various properties of soil. And different types of materials are used as soil stabilizers and an above discussion is helpful to decide the effective materials for soil stabilization. Also, we can decide the percentage of materials added to the soil. However, this review paper is also helpful to focus the different properties material depends upon the experimental results.

References

[1] E. Ravi, R. Udhayasakthi, T. Senthil Vadivel, "Enhancing the Clay Soil Characteristics using Copper slag Stabiliation",Journal of Advances in Chemistry, Vol.12, Issue No. 26, December 2016.
[2] Monica Malhotra, Sanjeev Naval, "Stabilization of Expansive Soils Using Low Cost Materials" International Journal of
Engineering and Innovative Technology, , Vol. 02, Issue No. 11, May 2013.
[3] Mohammed A. Qureshi, Hevin M. Mistry, Vikas D. Patel,"Improvement in Soil Properties of Expansive Soil by Using Copper
Slag", International journal of Advance Research in Engineering in Science and Technology, Vol.2, Issue No.07, July 2015.
[4] Brajesh Mishra, ravi Shanker Mishra, "A Study on Stabilization of Black Cotton Soil Use of Fly Ash, ferric Chloride and
Stone Dust", International Journal of Engineering and Science, Vol.5, Issue No. 10, PP- 20-25, October 2015.
[5] Jink chandrshekhar, Timir A Chokshi, "A Review on Utilization of Waste Material Copper Slag in Geotechnical Applications", International Journal for Innovative Research in Science and Technology, Vol. 1, Issue No.12, May 2015.

[6] Jayapal, S.Boobathiraja, M.Samuel Thanaraj, K.Priyadharshini, "Weak soil stabilization using different admixtures A
comparative study", International Journal of engineering research and technology, Vol 3, Issue No.10, October 2014.
[7] George Rowland otoko, Braide K. Honest, "Stabilization of Nigerian deltaic laterites with saw dust ash", International
Journal of scientific research and management, Vol 2, Issue No.8, August 2014.
[8] Tushal baraskar, S.K Ahirwar, "Study on California bearing ratio of black cotton soil use waste copper slag', International
Journal of structural and civil engineering research", Vol.3, Issue no.4, November 2014.
[9] Karthik.S, Ashok Kumar. E, Gwtham. P, Elango. G, Gokul. D, Thangaraj. S, "Soil Stabilization by Using Fly Ash", IOSR
Journal of Mechanical and Civil Engineering, Vol. 10, Issue No.6, Jan 2014, PP 20-24