Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Improving of Soil Properties with Partial Replacement of Ceramic Waste and Flyash

Gope Rajamouli, Chapalamadugu Chanti, Budde Nagalakshmi, Bathini Vinay,
Ala Swathi Sree, M. Srinivas Phani Kumar
UG Students – Final Year, Associate Professor
Department of Civil Engineering NRI Institute of Technology, Agiripalli, India

Abstract:- **Fly ash is a waste product obtained from coal-based thermal power stations. In the absence of proper utilization, large quantities of Fly ash are dumped in the landfills. Since traces of heavy metals are present in coal, the dumping of Fly ash in landfills is not ecofriendly and leads to air pollution and groundwater contamination. The ceramic tile waste is obtained from construction and tile industries which poses disposal problems and requires dumping areas causing environmental concerns. The combination of these materials offers a sustainable and cost-effective solution for stabilizing soil. Mix proportions of fly ash and ceramic tiles powder is 5%, 10% and 15%. We can replace the materials with the soil. By using this combination we can improve strength, durability and load bearing capacity.**

Keywords: **Stabilization, Fly ash, Black cotton soil and Ceramic tiles powder**

1. INTRODUCTION

Clayey soils are problematic soils having poor strength and beating capacity. Engineers face many problems while constructing facilities on such soils. Clayey soils do not possess sufficient strength to support the loads of the structure coming on them during construction or service life of the structure. Clayey soils are spread over more than one third part of the country. The main objective of the soil stabilization is toimprove the strength and stiffness of the soil. There are many methods are available to improve the properties and performance of the soil. The various methods of soil stabilization includes replacing the existing poor soil with another soil having good properties, blending it with some another soil or material to improve its properties, use of solid waste from different industries, addition of fibrous material to increase the strength of soil or use of some chemical additives to improve the characteristics of soil.

2. LITERATURE REVIEW

Phani et al. (2004) saw that the hydraulic conductivity, swelling properties and plasticity of expansive ash mixture decreased, whereas the strength and dry unit weight increased with the increase of fly ash content in the mix. given water content, the resistance to penetration also increased with the increase in fly ash content.

Barzesh et al. (2012) has also found the positive effects of egg shell powder on properties of expansive soil.

Eberemu et al. (2012) had investigated the stabilizing effects of glass cullet on engineering properties of expansive soil. The glass cullet's added were from 5 - 20 % at an increment of 5 %. With increase in percentage addition of glass cullet, there was continuous decrease in WL, WP, OMC, C, Ps and continuous increase in Ip, specific gravity (G), MDD, UCS, Ø, CB.

Gandhi (2012) studied the impact of addition of bagasse ash (up to 10 %) on hquid limit, plastic limit, plasticity index, shrinkage limit, shrinkage index, free swell index and observed a decrease in every one of these qualities with increase in percentage of bagasse ash.

Kiran and Kiran (2013) reported stabilization of soft soil with bagasse ash (4 %. 8 % and 12 %) alongside cement (4 %, 8 %, and 12 %) and lime (2 %. 4 % and 6 %,). The bagasse ash alongside cement and lime altered soil was assessed using compaction and California bearing ratio (CBR) and unconfmed compressive strength test.

Sharma and Chayan (2013) Rapid growth of industrialization produces hazardous waste material at large extent. If there is any fault in disposal process of waste materials then they act as a pollutant and also affect the ecological system of environment. It shows that there is argent need of exploring the alternative of disposal of these materials. In current practice, these waste material may be good alternative as a construction materials. This paper shows the influence of waste materials such as Beas river sand, Fly ash on compaction, and Strength characteristics of black cotton soil. The utilization of these materials have measurable advantages on the economy as well as the strength when used as construction materials.

Manikandan and Moganraj (2014) presented the combined impact of bagasse ash and lime on consolidation characteristics of expansive soil along with the impro\ed other properties.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Prakash and Nagakuniar (2014) examined the impact of bagasse powder on black cotton soil in addition with blast furnace slag. The performance of stabilized soil was assessed utilizing physical and strength tests in particular; for plasticity index, specific gravity, compaction, California Bearing Ratio (CBR). unconfmed Compressive Strength.

Ramadhan and Adedokun (2014) "Improving the Bearing Strength of Sandy Loam Soil Compressed Earth Block Bricks Using Sugarcane E^agasse Ash", sustainabilit>' ISSN 2071-1050 /journaLsustainability.

Akshaya (2014) Expansive soil is a problematic soil for civil engineers because of its low strength and cyclic swellshrink behaviour. Stabilization using solid wastes is one of the different methods of treatment, to improve the engineering properties and make it suitable for construction. The beneficial effects of some prominent solid wastes as obtained in laboratory studies, in stabilization of expansive soil have been discussed in this paper. Expansive soil is a term generally applied to any soil or rock material that has a potential for shrinking or swelling under changing moisture conditions.

Babita et al. (2014) studied the strength characteristics of expansive soil mixed with foundry sand, fly ash and tile waste. The compaction properties and CBR value were studied using different proportion of foundry sand, fly ash and tile wastes. The maximum dry density of clay-foundry sand (60:40) mix decreased with addition of fly ash which is a light weight material as compared to clay and foundry sand. The highest value of maximum dry density was achieved for clay-foundry sand-fly ash-tile waste mix of 54:36:10:2.25 followed by other proportions. The California bearing ratio value of clayey soil improved significantly i.e. from 2.43 % to 7.35 % with addition of foundry sand , fly ash and tile waste in appropriate proportion.

Ashish et al. (2015) examined the ehange in the soil properties with bagasse ash in different percentages (2. 5. 7 and 10 %). The test outcome for liquid limit, plastic limit, and standard proctor test were obtained on soil. The results demonstrate that with the increment in the proportion of bagasse ash, liquid limit and plastic limit get reduced.

Raghudeep and Prasad (2015) had mixed the available clayey soil with vitrified polish waste (VPW) up to 10 % for flexible pavement construction. At 10 % mix proportion of VPW, Liquid limit and Plasticity index of the soil decreased by 17.29 % and 42.77 %. The MDD increased by 13.61 % and DFS decreased by 27.93 % when 10 % VPW added to the soil. Soil classification changes from the CI to CL. CBR value increases from 2.1 % to 7.07 %. Soaked and Unsoaked CBR values increased 3 to 4 times when 10% of VPW added to the soil compared to original clayey soil.

Rakhil and Devi 2016 This behavior causes the volume change of the soil and it results the cracking and failure of structures built on that soil. To improve the geotechnical properties of this expansive soilso as to make them suitable for construction purposes, various methods are in available.

Sharma and Hymavathi 2016 Differential free swell (DFS) and MDD decreased while, pH, UCS and soaked CBR values increased with the use of additives

Rivera et al., 2020 Soil with maximum content of sand had higher dry density. The alkali activated stabilised soil block as raw materials improved the soil properties.

3. EXPERIMENTAL STUDY

3.1 Black cotton soil: Black cotton (BC) Construction of foundation in black cotton soil is very risky due to its swelling and shrinkage property as well as its bearing capacity is also very less. Black cotton soil does not take a higher load. It is required soil stabilization for improving its property or well process for construction of the foundation.

Figure 1: Black cotton soil

3.2 Fly ash: Fly ash acquired from power stations causes removal challenges and environmental concerns. Disposal concerns can be solved by employing these waste materials as a raw source to improve soil stability. Stability of soil refers to the improvement of soil behaviour due to the enhancement of the soil's geotechnical properties. Water content, strength, plasticity, and density are the most often adjusted properties. Generally, it can be said that fly ash improved the soil stability, especially in terms of CBR values, the permeability of the soil and decreased the potential of volumetric soil changes through a series of experimental tests. This is due to the size and shape of particles; in addition to the treated period, volumetric dilation of the ground is reduced.

Figure 2: Fly ash

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

3.3 Ceramic tiles powder : Ceramic waste was used in powder form. Engineering properties of soil and mix specimens were evaluated by performing various laboratory tests such as Consistency Limit, DFS Test, UCS Test, Standard Proctor Test, and CBR Test. As per Indian Standard Codes[6]–[11]. The ceramic waste powder was added with the expansive soil in different proportions such as 10 %, 15 %, 20 %, 25 %, 30 %, 35 %, and 40 % by weight of soil. Laboratory tests revealed that after adding ceramic tile waste, soil's plasticity changed from intermediate plastic clay (CI) to low plastic clay (CL). It was observed from the results of mentioned laboratory tests that the overall engineering properties of expansive soil were improved after adding the ceramic tile waste. The Optimum dose of ceramic waste powder was found to be 30 %.

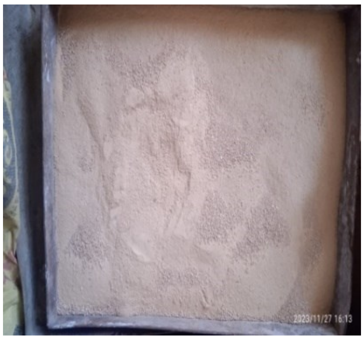

Figure 3: Ceramic tiles powder

3.4 METHODOLOGY

B_1 = Only Black cotton soil
B_2 = 5 % Flyash + 5 % tiles powder + 90 % BCS
B_3 = 10 % Flyash + 10 % tiles powder + 80 % BCS
B_4 = 15 % Flyash + 15 % tiles powder + 70 % BCS

4.TEST RESULTS

4.1 FREE SWELL INDEX

This is performed by pouring 10g of dry soil, passing through 425 micron sieve, into 100 cc graduated cylinder filled with water. The volume of swelled soils is read after 24 hours.

$$\text{Free swell (\%)} = \left(\frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}}\right) \text{x } 100$$

TABLE: 1 Test results of swelling

% of swelling	**B_1**	**B_2**	**B_3**	**B_4**
	70	**40**	**20**	**00**

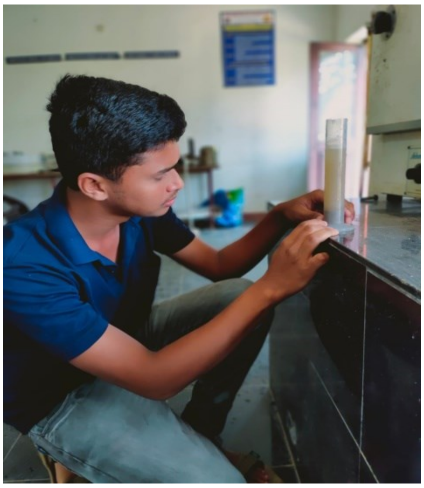

Figure 4: Swelling test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

4.2 LIQUID LIMIT

Liquid limit is the watercontent where the soil starts to behave as a liquid. Liquid limit is measured by placing a clay sample in a standard cup and making a separation (groove) using a spatula. The cup is dropped till the separation vanishes. The water content of the soil is obtained from this sample.

TABLE: 2 Test results of liquid limit

Liquid limit at 25 blows (%)	B_1	B_2	B_3	B_4
	45	36	33	28

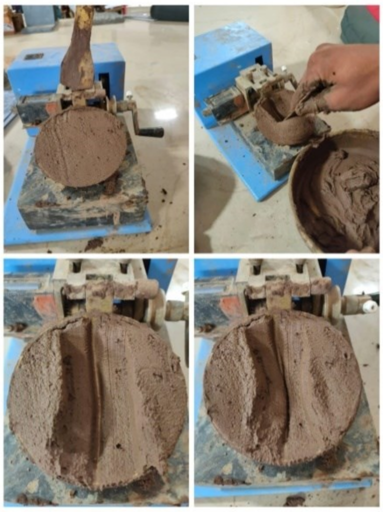

Figure 5: Liquid limit test

4.3 PLASTIC LIMIT

Plastic limit (PL) is the moisture content at which a fine-grained soil cannot be remolded without cracking. The plastic limit test requires repeated rolling of a soil sample into a thread until it reaches a point where it crumbles.

TABLE: 3 Test results of plastic limit

Plastic limit	B_1	B_2	B_3	B_4
	38.88	26.25	21.71	15.63

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Figure 6: Plastic limit test

4.4 PLASTICITY INDEX

The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL).

TABLE: 4 Test results of plasticity index

Plasticity index (%)	B_1	B_2	B_3	B_4
	6.12	9.75	11.29	12.37

4.5 SPECIFIC GRAVITY USING PYCNOMETER

The ratio of specific gravity of the solid to the specific gravity of water. It can be obtained by measuring the weight of the solid to the weight of water occupying equivalent volume of water

TABLE: 5 Test results of specific gravity

Specific gravity values	B_1	B_2	B_3	B_4
	2.28	2.41	2.54	2.60

Figure 7: Specific gravity test

4.6 STANDARD PROCTOR COMPACTION TEST

Densification of soil by reducing air voids by application of mechanical energy to improve their strength by increasing their unit weight

TABLE: 6 Test results of Standard proctor compaction test

Standard proctor compaction test	B_1	B_2	B_3	B_4
Optimum moisture content (OMC) (%)	23.52	15	11	12
Maximum dry density (MDD) (g/cc)	1.62	1.77	1.78	1.90

Figure 8: Standard proctor compaction test

4.7 CALIFORNIA BEARING RATIO (CBR)

The California Bearing test is an empirical test for determining the relative bearing ratio & expansion characteristics under known surcharge weight of base, sub-base and sub-grade soils for design of roads, pavements & runways.

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

TABLE: 7 Test results of CBR TEST

California Bearing ratio test	B_1	B_2	B_3	B_4
CBR (%) at 2.5mm penetration	0.13	0.58	0.61	0.61
CBR (%) at 5mm penetration	0.10	0.64	0.74	0.85

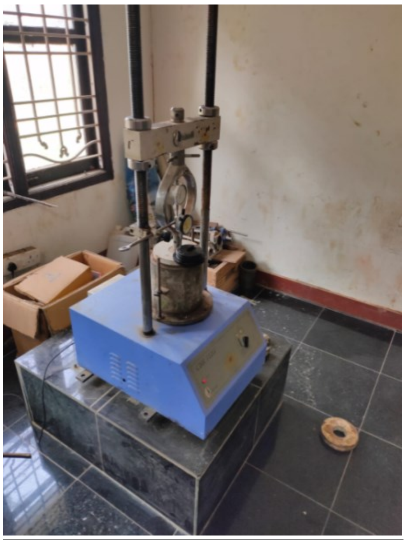

Figure 9: CBR test

4.8 UNCONFINED COMPRESSION TEST

The unconfined compression test is a type of triaxial test in which the confining pressure is taken as zero. The test is onlybe conducted in clayey soil specimens which can stand without confinement because of this case. The test is generally performed on intact (non-fissured), saturated clay specimens.

TABLE: 8 Test results of unconfined compression test

	B_1	B_2	B_3	B_4
Cohesion C_u (kg/cm^2)	106.81	214.18	267.64	343.01

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

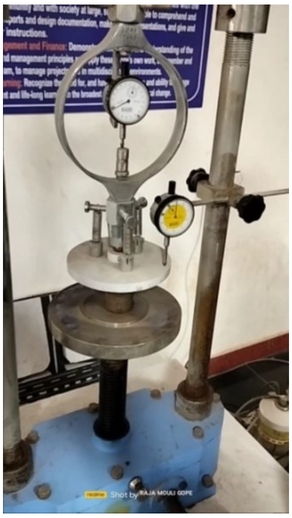

Figure 10: Unconfined compression test

4.9 GRAIN SIZE ANALYSIS

Sieve analysis is a method that is used to determine the grain size distribution of soils that are greater than 0.075 mm in diameter. It is usually performed for sand and gravel but cannot be used as the sole method for determining the grain size distribution of finer soil

TABLE: 9 Test results of grain size analysis test

Grain Size Analysis Test	B_1	B_2	B_3	B_4
Co efficient of uniformity (C_u)	3.78	8.21	6.64	5.46
Co efficient of curvature (C_c)	0.82	0.89	1.22	1.05

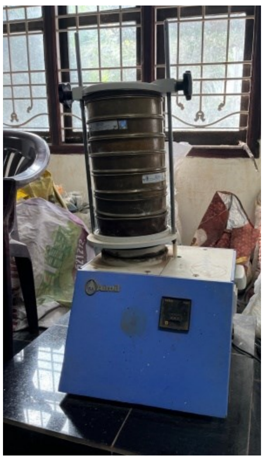

Figure 11: Grain size analysis test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

5. CONCLUSIONS

Based on the laboratory tests conducted on black cotton soil mixed with the fly-ash (0 to 15 %) and ceramic tiles powder (0 to 15 %) . Following conclusions can be drawn:

- With the addition of ceramic tiles powder and flyash liquid limit, plastic limit and plasticity index of the black cotton soil decreases.
- Optimum moisture content of the black cotton soil decreases as the percentage of ceramic tiles powder and flyash increases.
- California bearing ratio of the black cotton soil increases with the increase in the percentage of ceramic tile powder and flyash.
- The unconfined compressive strength of the black cotton increases as percentage of ceramic tiles powder and flyash increases.
- The differential free swell of black cotton soil decreases as the percentage of ceramic tiles powder and flyash increases.
- Specific gravity of black cotton soil increases as percentage of ceramic tiles powder and flyash increases.
- Liquid limit of samples are decreasing with the increasing of flyash and ceramic tiles powder into the black cotton soil. It has been found that the liquid limit decreased.

REFERENCES

- Phanikumar, B.R. and Sharma, R. S. (2004), "Effect of Fly Ash on Engineering Properties of Expansive Soil", Journal of Geotechnical and Geoenvironmental Engineering. Vol. 130, Issue 7, pp.764-767
- Barazesh, A., Saba, H., Gharib, M. and Rad, M.Y. (2012) "Laboratory Investigation of the Effect of Eggshell Powder on Plasticity Index in Clay and Expansive Soils," European Journal of Experimental Biology, 2 (6), 2378-2384. 10. Basha, E.A. Hashim, R. and Muntohar, A.S. (2003) 'Effect of the Cement- Rice Husk Ash on the Plasticity and Compaction of soil," Electronic Journal of Geotechnical Engineering, 8 (A).
- Eberemu, A.O., Amadi, A.A. and Lawal, M. (2012) "The Geotechnical Properties of Black Cotton Soil Treated with Crushed Glass Cullet," Nigerian Journal of Technological Research, 7(2), 23-30.
- Gandhi. K.S. (2012). "Expansive Soil Stabilization Using Bagasse Ash"". International Journal of Engineering Research & Technology (I.IERT), Vol-1, Issue 5.
- Dr. Ravi Kumar Sharma & Chayan Gupta "Influence Of Waste Materials On Geotechnical Characteristics Of Expansive Soil" IJERT-2013.
- Kiran. R.G and Kiran. E (2013). "Anahsis of Strength Characteristics of Black Cotton Soil Using E^agasse Ash and Additives as Stabilizer'". International Journal of Engineering Research & Technology (IJERT), Vol-2, Issu
- Babita singh, Ravi kumar (2014), "Evaluation of Geotechnical properties of clayey soil blended with waste materials", Jordan Journal of civil engineering, volume-8 Nov-2 2014.
- Akshaya Kumar Sabat"A Review Of Literature On Stabilization Of Expansive Soil Using Solid Wastes" EJGE-2014.
- Manikandan. A.F. and Moganraj. M. (2014). "Consolidation and Rebound Characteristics of Hxpansive Soil Using Lime and Bagasse Ash"". International Journal of Engineering Research & Technology (IJERT). eISSN:2319-! 163. pISSN:2321-7308.
- Cha\an. P and Nagakumar. M.S. (2014). "Studies on Soil Stabilization by Using Bagasse Ash"". International Journal of Scientific Research Engineering and Technology (IJSRET) ISSN:2278-0882.
- Ramadhan and Adedokun. D. A, (2014). "Improving the Bearing Strength of Sandy Loam Soil Compressed Earth Block Bricks Using Sugarcane E^agasse Ash", sustainabilit>' ISSN 2071-1050 /journaLsustainability.
- Raghudeep V., Prasad K.S.V.(2015),"Improvement in CBR value of Black cotton soil by stabilizing it with vitrified polish waste", International Journal of innovative research in science engineering and technology ,ISSN:2319-8753 vol.-4 Issue, 8 August 2015
- Murari. A.. Singh. I.. Agarwal. N. and Kumar. A. (2015). '•Stabilization of Local Soil with Bagasse Ash"". SSRG International .lournal oi'Ci\il engineering (SSRCi-LICE)- EFES.
- Sharma RK, Hymavathi J. Effect of fly ash, construction demolition waste and lime on geotechnical characteristics of a clayey soil: a comparative study. Environmental Earth Sciences, 2016, 75: 377.
- Rakhil Krishna R &Devi Krishnan "Review On The Effect Of Waste Ceramic Dust On The Geotechnical Properties Of Expansive Soils"IRJET-2016.
- Rivera JF, de Gutiérrez RM, RamirezBenavides S, Orobio A. Compressed and stabilized soil blocks with fly ashbased alkaliactivated cements. Construction and Building Materials, 2020, 264: 120285.