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Effect of Curing Strength in Lime – Coffee Husk Ash Mixture on Clay.

Efecto de la fuerza de curado en mezcla de cal y ceniza de cascarilla de café sobre arcilla.

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ABSTRACT

This study has been carried out to investigate the utilization of coffee husk ash for improving properties of clay collected from Kumarakom, Kottayam district, Kerala. Coffee husk is a waste from coffee factories. In order to provide a solution for reducing the disposal problem, utilization of waste in civil engineering works is very important. Kumarakom clay is known to be very problematic in construction field. It is considered neither suitable for building houses nor for construction of roads. Coffee husk is a by-product of coffee roasting process. After removal of coffee beans, a huge amount of coffee husk is generated later, the ash obtained after burning of coffee husk i.e; Coffee Husk Ash (CHA) is used in this study. The Kumarakom clay can be stabilized with different percentages of coffee husk ash and variation in strength can be determined by Unconfined Compression Strength (UCS) test and proctor compaction test. The optimum percentage is obtained at 20% of CHA addition. Finally, the curing strength test is conducted for varying percentages of CHA – clay mix and optimum percentage of CHA – lime mix for about 7, 14, and 28 days.

Keywords: Kumarakom clay, Coffee husk ash, Unconfined Compression Strength, Proctor compaction, Curing Strength.

RESUMEN

Este estudio se llevó a cabo para investigar la utilización de la ceniza de cáscara de café para mejorar las propiedades de la arcilla recolectada en Kumarakom, distrito de Kottayam, Kerala. La cascarilla del café es un desperdicio de las fábricas de café. Para proporcionar una solución que reduzca el problema de la eliminación, es muy importante la utilización de residuos en obras de ingeniería civil. Se sabe que la arcilla Kumarakom es muy problemática en el campo de la construcción. No se considera apto para la construcción de viviendas ni para la construcción de carreteras. La cáscara de café es un subproducto del proceso de tostado del café. Después de la extracción de los granos de café, se genera una gran cantidad de cáscara de café, la ceniza obtenida después de quemar la cáscara de café, es decir; En este estudio se utiliza ceniza de cáscara de café (CHA). La arcilla Kumarakom se puede estabilizar con diferentes porcentajes de ceniza de cáscara de café y la variación en la resistencia se puede determinar mediante la prueba de resistencia a la compresión no confinada (UCS) y la prueba de compactación Proctor. El porcentaje óptimo se obtiene con una adición del 20%

de CHA. Finalmente, la prueba de resistencia al curado se realiza para porcentajes variables de CHA – mezcla de arcilla y porcentaje óptimo de CHA – mezcla de cal durante aproximadamente 7, 14 y 28 días.
Palabras clave: Arcilla Kumarakom, Ceniza de cáscara de café, Resistencia a la compresión ilimitada, Compactación Proctor, Resistencia al curado.

INTRODUCTION

Kumarakom is popular for backwater tourism, located near the city of Kottayam in Kerala. The soil of the farm is riverine alluvium in texture. Soil may be defined as the upper layer of earth having air, water, and hard elements formed by fragmentation of rocks. Soil is the most important media for any kinds of construction works all over the world. Soil improvement is the main aspect in the construction field due to fast growth of urbanization and industrialization. Soil stabilization is a basic term for any physical, chemical, mechanical, biological or combined method of changing a natural soil to meet an engineering purpose. Stability of structures depends upon the strength properties of ground soil on which it is constructed. Structures basically, transfer all the loads coming on it directly to the ground. If the soil which is underlying is not stable for supporting the transferred loads then, there will be a chance of various types of failures to occur. The failures may be due to settlement of the structures, tilting of structures etc and so on. For solving these types of issues, soil improvement is necessary. By lowering the construction cost the risk of damage of structures can be maintained by soil improvement. Nowadays, numerous improvement methods are availabl

MATERIALS AND METHODS

The materials used in the experimental work are, clay collected from Kumarakom, Coffee Husk Ash (CHA), and Lime. In present work, clay was collected from Kumarakom, Kavanattinkara, Kottayam. It was dark brown in colour. Clay used for the test was air dried before tests. Coffee husk ash is produced from burning coffee husk from coffee factories. It was blackish in colour. In present work, lime was collected from Chandiroor, Cherthala, Alappuzha. It was white in colour. Lime is a calcium containing inorganic substance composed of oxide and hydroxides. The word lime originates from its early use as a building mortar and has a sense of sticking and adhering property. These are still used in large quantity as building and engineering materials.

Table 1. Initial properties of Clay

General characteristics	Natural moisture content (%)	Specific gravity	Sand (%)	Silt (%)	Clay (%)	Liquid limit (%)
Laboratory value	101	2.7	12	26	62	92

Plastic limit (%)	Plasticity index (%)	IS classification	Optimum moisture content (%)	Maximum dry density (g/cm^3)	Unconfined compressive strength (kN/m^2)	Free swell index (%)
42	50	CH	28	1.38	25	50

Table 2. Chemical properties of Coffee Husk Ash (CHA)

Chemical constituents	SiO_2	Fe_2O_3	CaO	MgO	SO_3	Na_2O
Percentage composition	1.26	0.47	13.5	4.62	3.56	0.07

$CaCO_3$	K_2O	Al_2O_3	MnO	TiO_2	P_2O_5	Loss Of Ignition
6.72	45.26	0.46	0.05	0.08	3.94	20.01

Table 3. Chemical properties of Lime

Chemical constituents	SiO_2	Fe_2O_3	CaO	MgO	S	Na_2O	C	K_2O	Al_2O_3
Percentage composition	0.01	0.12	64.25	0.50	0.13	0.01	4.50	0.01	0.01

The various tests like moisture content test, Specific Gravity, Atterberg's Limit, Proctor compaction test, Unconfined Compressive Strength, Swell tests and hydrometer test were conducted on the pure soil. Proctor compaction and Unconfined Compression Strength test on clay - CHA mix were conducted. Coffee husk ash is added to clay and the improvement in the properties of clay was analyzed. The material is added in different percentages as 5, 10, 15, 20 and 25. The optimum percentage is obtained as 20% for stabilizing the clay-CHA mix. The standard proctor compaction test and Unconfined Compressive Strength were determined on combination with 20% CHA and 6% lime in Kumarakom clay.

Standard proctor test: The standard proctor test is conducted for 20% Coffee Husk Ash and 6% lime from literature review as a part of stabilizing the clay collected from Kumarakom[12].

Unconfined compressive strength: The Unconfined Compressive Strength test is conducted for 20% Coffee Husk Ash and 6% lime on clay.

Curing strength test: A required amount of soil for curing strength test was taken. Mix the soil with the material thoroughly and add required water for further mixing. In this test, a cylindrical specimen of 3.8 cm in diameter is subjected to axial compression without any lateral pressure. The unconfined compressive strength can be defined as the compressive load per unit area at the time of failure of the soil sample. First of all, take the internal diameter of the split mould. The required amount of soil to fill the mould was mixed thoroughly with sufficient amount of water to attain a particular proportion. Oil the mould and fill it with soil. Care should be taken no entrapping of air may enter the soil during forming process. Extrude the soil from mould with sample extractor. Measure the initial length and diameter of sample.

Fig 1. Soil specimen get wrap with foil paper

Fig 2. Spraying of water

Fig 3. Soil sample after spraying of water

Fig 4. Crack formation during UCS test

Wrap the soil specimen with a foil paper and kept the specimen for 7, 14 and 28 days for checking the curing strength of soil-CHA mix with varying percentage of CHA as 5, 10, 15, 20 and 25%. After 2-3 days water can be sprayed over it. Finally, place the specimen in the bottom plate and make the upper plate to contact with the specimen.

Fix the proving ring reading and dial gauge reading and note down the initial readings. Apply compression load by giving about half a turn of the handle per second till thesample fails. Record the readings of the dial gauge and proving ring corresponding to each deformation. Plot the stress-strain curve for 7, 14, and 28 days for curing strength test.

RESULTS AND DISUSSION

Standard proctor test: The compaction test was carried out for 20% CHA and 6% lime on clay collected from Kumarakom. The maximum dry density and optimum moisture content obtained is shown in Table 4.1.

Table 4. Results of MDD and OMC variation on addition of 20%Coffee Husk Ash (CHA) and 6% lime

Addition of Coffee Husk Ash (CHA) and lime (%)	Optimum Moisture Content (OMC) (%)	Maximum Dry Density (MDD) (g/cm^3)
20% CHA + 6% lime	15.15	1.70

Unconfined compressive strength (UCS) test: The unconfined compressive strength test was carried out for 20% CHA and 6% lime on clay collected from Kumarakom. The unconfined compressive strength obtained is shown in Table 4.2.

Table 5. Results of UCS variation on addition of 20% Coffee Husk Ash (CHA) and 6% lime

Addition of Coffee Husk Ash (CHA) and lime (%)	Unconfined Compressive Strength (kN/m²)
20% CHA + 6% lime	3.6

Curing strength test: The soil – CHA mix in which different percentages of CHA as 5%, 10%, 15%, 20% and 25% is used for conducting UCS for determination of curing strength. The UCS variation in clay with addition of CHA in different percentages for 7 day, 14 day and 28 day curing strength is shown in Table 4.3.The curing strength variation chart is shown in Fig 4.1. for 7 day, 14 day and 28 days on addition of CHA in varying percentage.

Table 6. Results of curing strength variation on addition of CHA in different percentages along with clay

Addition of Coffee Husk Ash (CHA) (%)	UCS for 7 day curing strength (kN/m²)	UCS for 14 day curing strength (kN/m²)	UCS for 28 day curing strength (kN/m²)
5	2.74	2.77	2.8
10	2.83	2.86	2.89
15	2.98	3.01	3.04
20	3.31	3.34	3.39
25	2.21	2.24	2.27

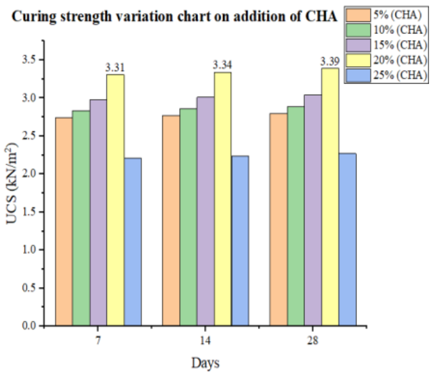

Fig 5. Results of curing strength variation chart on addition CHA in different percentages

The Soil - CHA– lime mix in which percentage of CHA as 20% and lime as 6% is used for conducting UCS for determination of curing strength. The UCS variation in clay with addition of CHA and lime in percentage for 7 day, 14 day and 28 day curing strength is shown in Table 4.4.

Table 7. Results of curing strength variation on addition of 20% CHA and 6% lime

Addition of Coffee Husk Ash (CHA) and lime (%)	UCS for 7 day curing strength (kN/m²)	UCS for 14 day curing strength (kN/m²)	UCS for 28 day curing strength (kN/m²)
20% CHA + 6% lime	3.64	3.68	3.75

The curing strength variation curve is shown in Fig 4.2. for 7 day, 14 day and 28 days on addition of 20% CHA and 6% lime in Kumarakom clay.

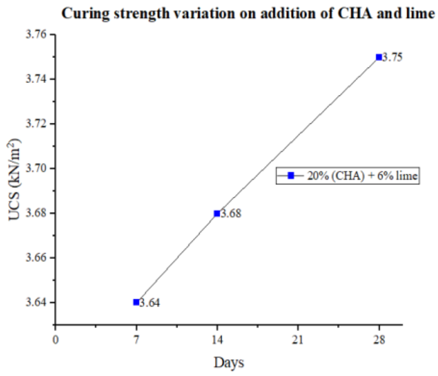

Fig 6. Results of curing strength variation chart on addition 20% CHA and 6% lime

REFERENCES

A.Gebissa., Atahu,M.K., F.Saathoff., 2019. Strength and compressibility behaviour of expansive soil treated with coffee husk ash, Journal of Rock Mechanics and Geotechnical Engineering. 111: 337-348.

Arwaedo,N., Chaiyaput,S., 2022. Effect of curing conditions on the strength of soil cement, Case Studies in Construction Materials. 16: 2214 – 5095.

Assefa,F., Shemekite,F., 2014. Coffee husk composting : An investigation of the process using molecular and non molecular tools, Waste management. 134 (3): 642-652.

B.Van der Bruggen., D.Dadi., 2019. Composting and co-composting of coffee husk and pulp with source separated municipal solid waste : a break through in valorization of coffee waste, International Journal of Recycling of Organic Waste in Agriculture. 108: 263-277.

Bang,C., Ma-cong., 2014. Analysis of strength development in soft clay stabilized with cement based stabilizer, Construction and Building Materials. 171: 354-362.

Bell,F.G., 1996. Lime stabilization of clay minerals and soils, Engineering Geology. 142 (4): 223-237.

Biznc,O.A., Canakci,H., 2016. Stabilization of clay using Waste Beverage Can, Procedia Engineering. 161: 595-599.

Chenarboni,H.A., Zeighami,E., 2021. The effect of zeolite and cement stabilization on the mechanical behaviour of expansive soils, Construction and Building Materials. 272.

Denede,D., Emmanuel,E., 2019. Insights on the clay reactivity in alkaline media : Beyond filler role for kaoline, Applied clay science. 181.

G.Garcia., Seco,A., 2011. Stabilization of expansive soils for use in construction, Applied clay science. 151 (3): 348-352.

Hasan,M., Winter,M.J., 2021. Effect of optimum utilization of silica fume and egg shell ash to the engineering properties of expansive soil, Journal of Material Research and Technology. 114: 1401-1418.

Ikeagwuani,C.C., 2019. Emerging trends in expansive soil stabilization : A review, Journal of Rock Mechanics and Geotechnical Engineering. 111 (2): 423-440.

Ikeagwuani,C.C., 2019. Stabilization of black cotton soil subgrade using sawdust ash and lime, Soils and

Foundation. 59.

Jafer,H., Lofill,E., 2018. Stabilization of soil using binary blending of high calcium fly ash and palm oil fuel ash, Applied clay science. 152: 323-332.

Kamei,T., Ugai,K., 2013. Durability of soft clay soil stabilized with recycled Bassanite and furnace cement mixture, Soils and Foundations. 153: 155-165.

Khemissa,M., Mahamedi,A., 2015. Stabilization of an expansive over consolidated clay using hydraulic binders, HBRC Journal. Vol 111 (1): 82-90.

Khoshghalb,A., Oluwatuyi,O.E., 2020. Cement lime stabilization of crude oil contaminated kaolin clay, Journal of Rock Mechanics and Geotechnical Engineering. 121: 160-167.

Leo,H.L., Lim,D.F., 2007. Sludge ash / hydrated lime on the geotechnical properties of soft soil, Journal of Hazardous materials. 145: 58-64.

Li Jiaming., Tang,S., 2022. Engineering properties and microstructure of expansive soil treated with nanographite powder, Journal of central south university. 129: 499-514.

Meeravali,K., Rangaswamy,K., 2020. Stabilization of soft clay using nanomaterial : Terrasil, Material Today : Proceedings. 127: 1030-1037.

Miraki,H., 2022. Clayey soil stabilization using alkali-activated volcanic ash and slag, Journal of Rock Mechanics and Geotechnical Engineering. 114 (2): 576-591.

Parthiban,D., 2022. Role of industrial based precursors in the stabilization of weak soils with geopolymer- A review, Case studies in construction materials. 116.

Rahmat,M.N., 2018. Effect of optimum compaction moisture content formulations on the strength and durability of sustainable stabilized materials, Applied clay science. 157: 257-266.

Sivapullaiah, P.V., Suganya, K. 2020. Compressibility of remoulded and cement treated Kuttanad soil, Soils and Foundations. 160(3): 697-704.

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