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An overview of an experimental study on stabilization of clayey soil using calcium carbide residue and fly ash.

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Abstract - *In order to improve soil engineering properties, stabilization is necessary. Clay soil is expansive soil and tends to expand on absorbing water and shrinks as water is drawn away. The current research article focuses on examining the strength behaviour of clayey soil utilizing industrial waste products like calcium-carbide-residue (CCR) and fly ash (FA). By maintaining an optimal ratio of CCR and FA in soil, soil properties can be enhanced. Therefore, the individual and combined effects of different proportions of CCR and FA are evaluated to compare the improvement of soil properties. Several tests such as the Atterberg limit test, Unconfined compressive strength (UCS) test and Compaction test are performed to determine the effectiveness of CCR and FA.*

***Key Words*: Soil stabilization, Calcium-carbide-residue, Fly ash, engineering properties.**

1. INTRODUCTION

The stabilization of soil is the process of improving the physical properties and strength of the soil so that it can be used over the long run. A soil's engineering properties like moisture content, shear strength, or other engineering properties are sometimes controlled chemically to provide the structural basis for roads, building pads, or parking lots.

This research is based on the stabilization of soil by using calcium-carbide-residue (CCR) and fly ash (FA). CCR is considered a by-product of the acetylene-based gas industry. Since it has no recovery value, it is usually dumped on open land or in a landfill in India.

CCR contains lime that increases the pH of the soil, causing the alumina and silica naturally present in clayey soils to dissolve. The chemical reaction of alumina and silica with the calcium in the soil produces calcium-silicate-hydrates (CSH) and calcium-aluminate-hydrates (CAH). The interactions between CSH and CAH are similar to those found when working with cement. They improve the bearing capacity of soils by forming long-term, permanent bonds.

In this study, we are investigating how industrial waste products can improve the strength of clayey soils, which is critical for improving the sustainability and resilience of soils. In particular, over years, improvement techniques have been employed with the addition of stabilizers to create a cementation bond between fine-grained soil particles.

2. REVIEW OF LITERATURE

Ayodele F. et al. (2022) have tried to find out the influence of binary blends of Rice Husk Ash (RHA) and Calcium Carbide Residue (CCR) on lateritic soil engineering properties. A noticeable improvement in soil consistency was noted. At different dosages of optimum CCR: RHA, the California Bearing Ratio improved for soil strength up to 6%. Overall, the stabilized soil strength as measured by UCS improved as additives were added. These additives improve the soil's ability to resist erosion. As the additive content of the soil increased, its plasticity decreased.

Latifi N. et al. (2018) have focused their study to examine CCR practicability to stabilize clay. Natural pozzolanic materials in clay can react with CCR following pozzolanic reactions. Tests indicated that a significant improvement in compressibility and strength has been observed utilizing CCR. The highest strength improvements in UCS tests were obtained with CCR dosages of 9% and 12% for bentonite and kaolin, respectively. After 28 and 90 days of curing, the UCS of the 9% added CCR tested bentonite increased by 4.7 and 6.8 times those of untreated soil respectively. Upon curing CCR-stabilized kaolin for 28 and 90 days, the UCS improved by 3.8 and 5.8 times, respectively.

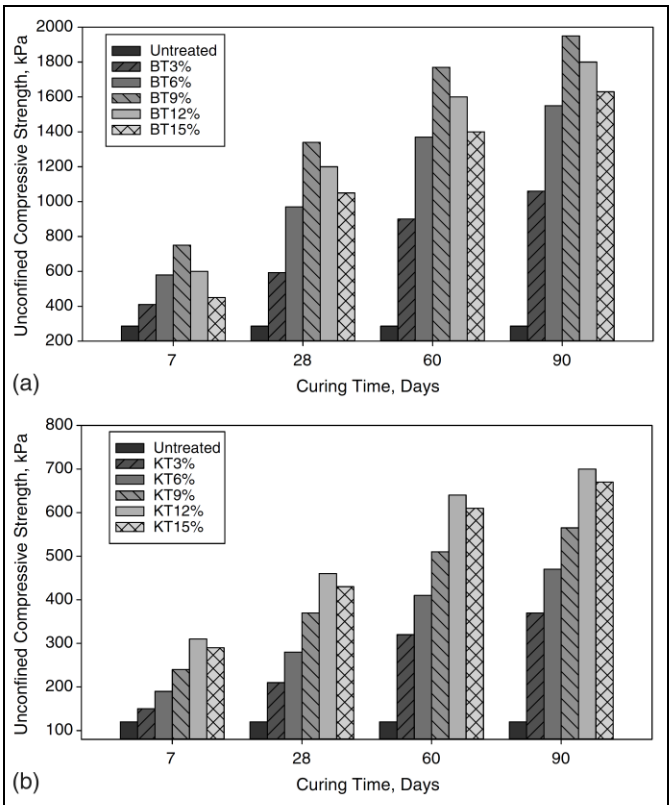


Fig. 1. Strength development in CCR-treated clays at different additive contents and curing times: (a) bentonite; and (b) kaolin.

Noolu V. et al. (2018) have observed that the use of CCR and fly ash has enhanced the index properties namely compaction characteristics and Atterberg limits to a great extent. It has also been noticed that up to 8% CCR addition, the strength properties like California bearing ratio and unconfined compressive strength increase significantly. There is a decreasing tendency for LL and PI when the CCR stabilized black cotton soil is provided with fly ash.

Jafer H et al. (2018) have successfully figured out the impact of palm oil fuel ash (POFA) pozzolanic reactivity on the soft soil engineering properties, stabilized with high calcium fly ash (HCFA). According to UCS and Atterberg limits the HCFA and POFA combination leads to higher compressive strength and lower plasticity index (PI) compared to the HCFA-based treated soil alone.

Murmu A. et al. (2018) have performed certain experiments by differing the content of fly ash in the range of 5% to 20% and handing the samples at a considerably least concentrated 5M NaOH solution. A laboratory test was conducted to determine the California bearing ratio, unconfined compressive strength, resilience modulus, and California bearing ratio of stabilized samples. The addition of fly ash from 0% to 20% has slightly decreased the liquid limit and increased the plastic limit.

Du Y. et al. (2016) worked on finding the mechanical properties of CCR stabilized soft clayey soil which is utilized as a subgrade course material for the highways. In an adjacent field section, Quicklime was used as a control binder to compare its performance with CCR.

Jiang N. et al. (2015) have compared the stabilized quicklime soil by conducting a multi-scale laboratory investigation focusing on the several properties viz., mechanical, physical and also microstructural of stabilized CCR clayey soils. It was observed that within the initial 28d, stabilized CCR soil has significantly lower pore volume as compared to stabilized quicklime soil. However, this difference in pore volume is almost negligible at 120d. A converse correlation was noticed between the stabilized soil and a larger volume of pore in the soil. At the initial stage, the vital contributor to the rapid and complete development of flocculation and agglomeration of soil particles are high pH value, significant specific area and fine size particle of CCR soil when compared to quicklime.

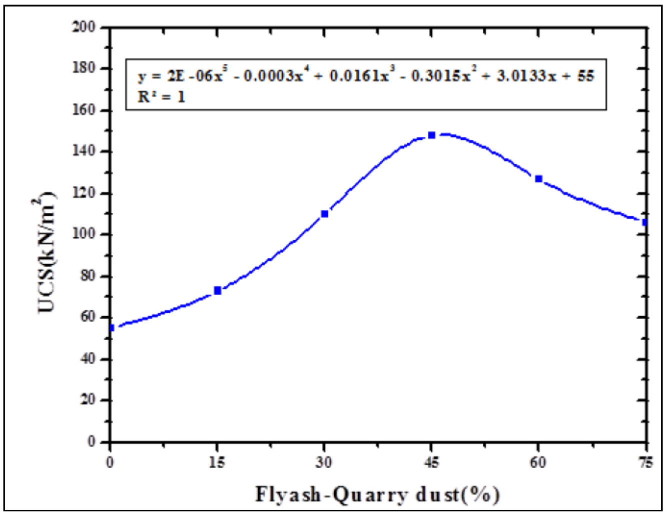
Raut J. et al. (2014) have tried to examine the property enhancement of expansive soil by varying the percentage of fly ash and murrum. With an increase in the percentage of fly ash and murrum, the MDD and unconfined compressive strength is found to be increasing till a certain limit and thereafter their value decreases. They have reported that the optimal combination for property enhancement of clay is attained by mixing 5% of fly ash and 7.5 % of murrum with it.

Kampala A. et al. (2013) have focused their study to have a basic idea about the engineering properties of stabilized CCR soil in its recycled form. Scanning electron microscopic (SEM) images manifest that the recycled form of stabilized CCR soil grains is bigger than the CCR and clay particles. The reason for this is the attached pozzolanic products with the recycled stabilized CCR soil. The large grains of the recycled CCR stabilized clay reduces linear shrinkage and free swell ratio. Since the hard pozzolanic products resist compaction, the recycled CCR stabilized clay has a lower unit weight compared to the CCR stabilized clay for the same amount of compaction energy and CCR content.

Vichan S. et al. (2013) have conducted experimental work to investigate the effects of blending CCR and biomass ash (BA) which acts as a stabilizing chemical additive, and leads to a pozzolanic reaction. Their research work suggests that calcium hydroxide $Ca(OH)_2$ was formed when CCR dissolves in water. Pozzolanic products were obtained by dissolving the amorphous Si from BA in a higher pH solution (pH=12.6). It has also been observed that the combined effects of CCR and BA on clay strength development were observed when the binder content reached 30% of the dry soil weight.

Horpibulsuk S. et al. (2013) have analyzed the improvement in the strength of stabilized CCR and FA clay. A very high $Ca(OH)_2$ content of 76.7% is found in CCR. A soil that contains a high percentage of natural pozzolanic material can be improved by using it alone. They also mentioned that if the natural pozzolanic material is completely absorbed by the input CCR, CCR and FA can be used together for higher strength requirements.

Sabat A. et al. (2013) have analyzed the mutual effects of two industrial wastes namely, fly ash and quarry dust on several properties such as compaction characteristics, shear strength parameters, UCS, California bearing ratio (CBR), and swelling pressure of expansive soil. The highest value for UCS is achieved concerning 45% fly ash-quarry dust mixture. The UCS value further decreases with an increment in its percentage. As the percentage of fly ash-quarry dust mixes increases, the MDD increases and the OMC decreases.



Tastan E. et al. (2011) have reported that blending fly ash into soft organic soils increases their unconfined compressive strength and resilient modulus. It is possible to increase the unconfined compressive strength of organic soils with an addition of fly ash, but the amount of advancement depends on soil type and fly ash characteristics. Stabilization is adversely affected by soil organic content. Soil with more organic matter will have less strength, indicating that soil with more fly ash will have less strength.

3. AIMS AND OBJECTIVES

1. To analyze the effect of stabilizers in engineering properties and index properties of clayey soil in an appropriate manner.
2. To investigate the improvement of soil properties such as the optimum content of moisture and maximum dry density.
3. To evaluate the individual and combined effects of the various proportion of CCR and FA to compare the improvement of soil properties.

4. METHODOLOGY

The experimental program can be divided into two phases. In the first phase, the effect of CCR on clayey soil is to be studied. Variation in Atterberg limits, UCS values, and CBR of clayey soil, when mixed with different percentages (by dry weight) of CCR, shall be studied. An optimum percentage of CCR is to be obtained based on the results obtained from the first phase. In the second phase, improvement in the properties of CCR stabilized clayey soil with the further addition of FA is to be studied. In this phase, the optimum percentage of CCR (from the first phase) added to the clayey soil, and the variation of its properties with different FA percentages shall be studied.

To experiment, these are the various tests that can be done by different proportions of CCR and FA.

a) Atterberg's limit test
b) Compaction test
c) Unconfined compressive strength test
d) California bearing ratio test

5. NEED FOR THE PRESENT STUDY

By reducing the soil's permeability and increasing its overall strength, the stabilization process ensures the soil's stability. This results in strong soil with enhanced bearing capacity. As CCR and FA are widely produced all over the world that leads to the production of a large amount of waste and it can be easily used for cost-efficiently soil stabilization.

6. CONCLUSIONS

After an extensive literature review as mentioned above, it has been noticed that there is scope for the enhancement of the strength of the soil by utilizing CCR and fly ash-

1. Most of the researchers have emphasized that a proper combination of CCR and fly ash is successful and efficient for improving several engineering properties of soil.
2. It will increase the unconfined compressive strength, shear strength, California bearing ratio etc.
3. The liquid limit and plasticity index of the stabilized CCR black cotton soil decrease with FA addition, while the plastic limit increases.

4. Using CCR and FA as a stabilizer is very economical and it also helps in reducing the waste creating an ecological hazard.

REFERENCES

[1] Ayodele, F.O., Fajimi, M.S. and Alo, B.A., 2022. Stabilization of tropical soil using calcium carbide residue and rice husk ash. Materials Today: Proceedings.

[2] Du, Y.J., Jiang, N.J., Liu, S.Y., Horpibulsuk, S. and Arulrajah, A., 2016. Field evaluation of soft highway subgrade soil stabilized with calcium carbide residue. Soils and Foundations, 56(2), pp.301-314.

[3] Horpibulsuk, S., Phetchuay, C., Chinkulkijniwat, A. and Cholaphatsorn, A., 2013. Strength development in silty clay stabilized with calcium carbide residue and fly ash. Soils and Foundations, 53(4), pp.477-486.

[4] Jafer, H., Atherton, W., Sadique, M., Ruddock, F. and Loffill, E., 2018. Stabilisation of soft soil using a binary blending of high calcium fly ash and palm oil fuel ash. Applied Clay Science, 152, pp.323-332.

[5] Jiang, N.J., Du, Y.J., Liu, S.Y., Wei, M.L., Horpibulsuk, S. and Arulrajah, A., 2015. Multi-scale laboratory evaluation of the physical, mechanical, and microstructural properties of soft highway subgrade soil stabilized with calcium carbide residue. Canadian Geotechnical Journal, 53(3), pp.373-383.

[6] Latifi, N., Vahedifard, F., Ghazanfari, E. and Rashid, A.S.A., 2018. Sustainable usage of calcium carbide residue for stabilization of clays. J Mater Civ Eng, 30(6), p.04018099.

[7] Murmu, A.L., Dhole, N. and Patel, A., 2020. Stabilisation of black cotton soil for subgrade application using fly ash geopolymer. Road Materials and Pavement Design, 21(3), pp.867-885.

[8] Noolu, V. and Pillai, R.J., 2018. Multi-scale laboratory investigation on black cotton soils stabilized with calcium carbide residue and fly ash. Journal of Engineering Research, 6(4).

[9] Raut, J.M., Bajad, S.P. and Khadeshwar, S.R., 2014. Stabilization of expansive soils using Fly ash and murrum. International Journal of Innovative Research in Science, Engineering and Technology, 3(7), pp.14280-14284.

[10] Sabat, A.K. and Bose, B., 2013. Improvement in geotechnical properties of expansive soil using fly ash quarry dust mixes. Electronic Journal of Geotechnical Engineering, 18, pp.3487-3500.

[11] Vichan, S. and Rachan, R., 2013. Chemical stabilization of soft Bangkok clay using the blend of calcium carbide residue and biomass ash. Soils and Foundations, 53(2), pp.272-281.

[12] Tastan, E.O., Edil, T.B., Benson, C.H. and Aydilek, A.H., 2011. Stabilization of organic soils with fly ash. Journal of geotechnical and Geoenvironmental Engineering, 137(9), pp.819-833.

[13] Horpibulsuk, S., Phetchuay, C. and Chinkulkijniwat, A., 2012. Soil stabilization by calcium carbide residue and fly ash. Journal of materials in civil engineering, 24 (2), pp.184-193.

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