 https://doi.org/10.1051/e3sconf/202452901015

Optimization of RHA and Cement proportion for soil stabilization

Ravi Shankar Raman[1*], *C Lavanya*[2], *Revathi V*[3], *Ginni* Nijhawan[4], *Dinesh Kumar* Yadav[5], *Q. Mohammad*[6], *Vandana* Arora Sethi[7]

[1]Department of Mechanical Engineering, ABES Engineering College, Ghaziabad - 201009, UP, India
[2]Department of Civil Engineering, GRIET, Hyderabad, Telangana-500090, India.
[3]Department of Applied Sciences, New Horizon College of Engineering, Bangalore, India
[4]Lovely Professional University, Phagwara, India
[5]Lloyd Institute of Engineering & Technology, Knowledge Park II, Greater Noida, Uttar Pradesh 201306
[6]Hilla University College, Babylon, Iraq
[7]Lloyd Institute of Management and Technology, Greater Noida, Uttar Pradesh, India-201306

Abstract. The process of changing a soil's physical characteristics to provide it long-term, permanent improvements in strength is known as soil stabilisation. Increasing a soil's overall bearing capacity and shear strength is how stabilisation is achieved. After stabilisation, a solid monolith forms, reducing permeability and hence the possibility for shrinkage and swelling as well as the damaging impacts of freeze-thaw cycles. The goal of this study is to improve the physical characteristics of soils for better building results by investigating the potential of cement and rice husk ash (RHA) as soil stabilizing materials. Using RHA, a byproduct of milling rice, this study investigates alternate, environmentally friendly stabilization techniques with respect to the limits of traditional cement-based stabilization. The study assesses the impacts of different RHA and cement mixtures on soil's Liquid Limit, Plastic Limit, and Plasticity Index using a thorough experimental approach. The factorial experiment provides important insights into changes in soil plasticity over a 3x3 matrix under nine distinct settings. The results show that while larger RHA percentages considerably lower the Plasticity Index, indicating improved soil stability, increasing cement concentration generally rises the Liquid and Plastic Limits. The satisfactory combination, determined to be 15% RHA and 8% cement, presents a possible path closer to producing soil that is less plastic and more durable. This obseravtion helps to broaden sustainable, low-cost techniques of stabilizing soil at the same time as also shedding light on the synergistic impacts of cement and RHA on soil parameters.

Keywords : Soil, Soil stabilization, RHA, cement, optimization techniques.

*Corresponding author: *ravi.raman21@gmail.com*

1 Introduction

An essential step in civil engineering is soil stabilization, which targets to strenghten the physical characteristics of the soil and make it more appropriate for construction usage. Even though cement is commonly used in conventional techniques, research into alternate materials has been brought on by means of economic and environmental concerns [1]. The pozzolanic qualities of rice husk ash (RHA) have made it a possible additive that may each reduce plasticity and increase soil power [2].

Chemical technique for Stabilizing remaining Soils -a thorough research discovered that including 6-8% cement and 10-15% RHA optimally lowers soil plasticity whilst influencing compactability through an increase in most appropriate moisture content and a decrease in most dry density [3]. Such changes highlight the benefits of the usage of RHA in soil stabilization from a monetary and environmental point of view, and that they suggest a balanced strategy to improving soil workability and strength.

Strengthening and Microstructural Examination - Subsequent studies on the stabilization of soft soils using a cement and RHA combination revealed appreciable increases in strength across 3, 7, 14, and 28-day curing times. Interestingly, it was discovered that a 30% RHA concentration worked best for substituting cement to some extent, resulting in soil strengths of 424, 722, 915, and 1,126 kPa, respectively, over these intervals [4]. X-ray diffraction examination reveals a correlation between the creation of calcium silicate hydrate and strength development, which suggests the chemical mechanisms responsible for the stabilization's efficaciousness.

Expansive Soil Stabilization- The usage of RHA along with calcium carbide residue (CCR) for expanding soil stabilization produced notable increases in the parameters related to swelling-shrink and strength. The optimum blending amount of 15% RHA was found, underscoring the function of RHA in improving soil stability via coagulation reaction, ion exchange, and replacement efficiency [5].

Clay-Sand Combinations with Changing Soil Properties- Studies on the stabilization of clay-sand mixtures using polypropylene (PP) fibers, cement, and RHA showed that adding 20% sand and RHA can eventually improve compressive strength. These results led to the development of a compressive strength prediction model that helps optimize clay stabilization mixtures [6-10]. A different study examined the dynamic behavior of sand stabilized with RHA in place of cement, and the results showed new correlations that could be used to evaluate the degradation index, shear modulus, damping, and unconfined compression strength. For the dynamic design of pile-supported foundations, those realizations are crucial [11-13].

Strengthening the Subgrade Soil's Mechanical properties - considerable mechanical upgrades have been determined in subgrade soil from a failed road section in Nigeria when RHA and cement kiln dirt (CKD) had been used in the research. 10% CKD and 8% RHA, activated with sodium hydroxide (NaOH), produced the high-quality consequences. In line with the objectives of sustainable improvement, this combination ended in significant cost savings [14].

Eco-sustainable alternatives for low-cost constructing - subsequent research highlights the possibility of employing CKD and RHA as stabilizers to enhance the characteristics of clayey soils, providing long-time period answers for less expensive constructing of infrastructure and homes. With the aid of the use of waste materials and locally accessible assets, these strategies assist environmental sustainability [15,16].

Indian Peat Stabilization Using GGBS and RHA - It was investigated whether ground granulated blast furnace slag (GGBS) and RHA might stabilize Indian peat in part by

replacing cement, with a maximum substitution of 30%. This approach worked well for low organic peat, demonstrating the sustainability of RHA and GGBS as substitutes [17].
Treatment of Coastal Soils and Stabilization of Laterite Soils- It was investigated how RHA stabilizes laterite soil, and it was found that higher RHA content improved UCS, CBR, and compaction properties. Its efficaciousness in stabilizing laterite soil was established when optimal performance was observed at 4-6% RHA [18-20]. The geotechnical behavior of soil from the Bagan Lalang coast treated with cement, lime, and RHA also shown notable changes in soil parameters, supporting the use of an inexpensive, green mixture as shown table 1 [10].

Table 1. Comparative analysis of studies conducted

Study Focus	Materials Used	Effects on Soil Properties	Optimal Content	Outcomes
Chemical Stabilization of Residual Soils	Cement + RHA	Reduces plasticity, affects compactability	6–8% Cement, 10–15% RHA	Improved workability and strength, economic and environmental benefits
Strength Enhancement and Microstructural Analysis	Cement + RHA	Increases soil strength, formation of calcium silicate hydrate	30% RHA	Significant strength improvements over curing periods, optimal for partial cement replacement
Expansive Soil Stabilization	RHA + CCR	Improves swelling-shrink and strength properties	15% RHA	Enhanced soil stability through replacement efficiency, coagulation reaction, and ion exchange
Clay-Sand Mixtures and Dynamic Soil Behavior	Cement, RHA, + PP Fibers	Enhances compressive strength over time	20% Sand + RHA	Aids in optimizing clay stabilization mixtures, crucial for dynamic design of foundations
Enhancing Mechanical Strength of Subgrade Soil	RHA + CKD + NaOH	Notable mechanical improvements	10% CKD, 8% RHA	Significant cost savings, alignment with sustainable development goals
Sustainable Solutions for Low-Cost Construction	RHA + CKD	Improves properties of clayey soils	Varied	Offers sustainable solutions for construction, utilizes locally available materials
Stabilization of Indian Peat with GGBS and RHA	GGBS + RHA	Effective for low organic peat	30% Cement Replacement	Indicates viability of GGBS and RHA as sustainable alternatives
Laterite Soil Stabilization and Coastal Soil Treatment	RHA + Cement/Lime	Improves compaction characteristics, CBR, and UCS	4-6% RHA	Demonstrates effectiveness in laterite soil stabilization, significant property improvements

There are several properties of materials that need to be studied properly for selecting it for any engineering application such as strength, toughness, plastic limit etc. [15-17]. There are studies that depict on boosting the filler content in the composite material, the strength reduces but the wear resistance of the composite improves [18]. The structure of the material after the tensile strength of the final Cement proportions [19]. Another study suggests that incorporating 10% calcined clay and 107 microbes into conventional concrete can enhance its strength and durability [20].

2 Design of experiment

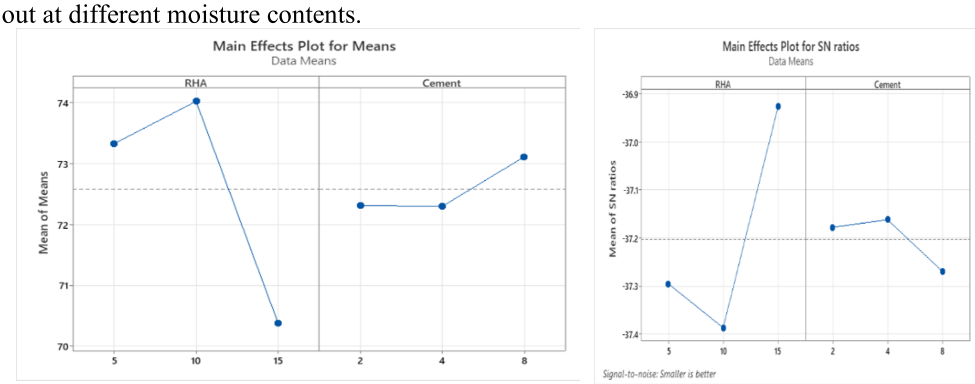
The primary objective is to assess the impact of different compositions of Rice Husk Ash and cement mixtures on the geotechnical properties of the soil, such as the Atterberg's Limit. For using soil in the construction industry, it is necessary to enhance the geotechnical properties of soil to make the soil more stable [21-24]. This study uses Taguchi as design of experiment to evaluate the properties of soil for stabilization. In Taguchi, two factors were considered at 3 different levels. The factors that vary across three levels are cement and RHA. Cement is evaluated at three different percentages i.e 2%, 4% and 8% concentrations, and RHA is considered at 5%, 10% and 15% concentrations. Thus two factors and three levels when provided to Taguchi in Minitab Software, L9orthogonal array was provided, which means total 9 combinations were going to be prepared by varying the composition of factors considered. Table 2 provides, the DOE of factors across different levels and the values of responses such such as Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI).

Table 2. Design of Experiment for soil stabilization using RHA and Cement

RHA	Cement	Liquid Limit	Plastic Limit	Plasticity Index
5	2	75.19	48.25	26.94
5	4	76.25	50.33	25.92
5	8	68.52	24.54	43.98
10	2	73.26	35.14	38.12
10	4	75.2	39.28	35.92
10	8	73.59	40.98	32.61
15	2	68.48	52.65	15.83
15	4	65.43	54.1	11.33
15	8	77.21	68.21	9

3 Liquid Limit

The water concentration at which soil changes from a liquid to a plastic form is known as the Liquid Limit (LL). It is the lowest moisture content at which a soil can move with little shear stress [25]. A cone penetrometer or the Casagrande cup method are used to find the limit. Since adjusting the moisture content of soil might be difficult, at least three tests are carried out at different moisture contents.



(b)

(a)

Fig 1. Plots for means and S/N ratio (a) main effect plot of RHA and cement for means (b) main Effect plot of RHA and cement for signal to noise ratio

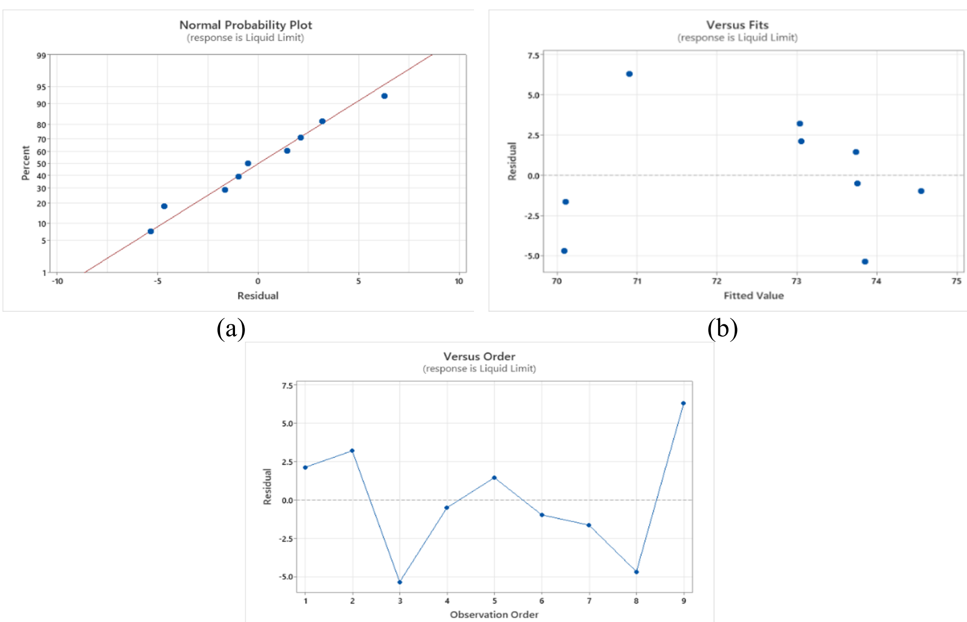
This study investigates the effects of RHA and cement on signal-to-noise (S/N) ratios. The first plot in Fig. 1(a) demonstrates that the values of RHA is high for 10%, then falls at 15%.

The RHA trend in the second plot in Fig. 1(b) shows that, with greater percentages indicating a positive correlation. While cement improves S/N ratios and then falls, the data indicate that there is an optimal amount of cement for reducing atterberg limits. This suggests that optimum quantities of RHA and cement generally result in lower atterberg limits and quality outcomes [26].

3.1 Regression Equation

The model uses Rice Husk Ash and cement percentages to determine soil behavior. Positive coefficients indicate increased Liquid Limit at higher concentrations, while negative coefficients indicate decreased Liquid Limit at lower concentrations [27-30]. The base value of 72.57 represents the Liquid Limit without additives, highlighting the complex interactions between soil and additives.

$$\text{Liquid Limit} = 72.57 + 0.75\ \text{RHA\_5} + 1.45\ \text{RHA\_10} - 2.20\ \text{RHA\_15} - 0.26\ \text{Cement\_2} - 0.28\ \text{Cement\_4} + 0.54\ \text{Cement\_8}$$



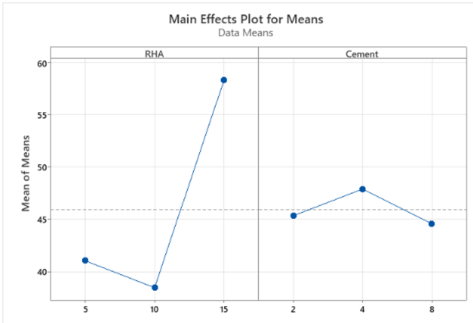
(a) (b)

(c)

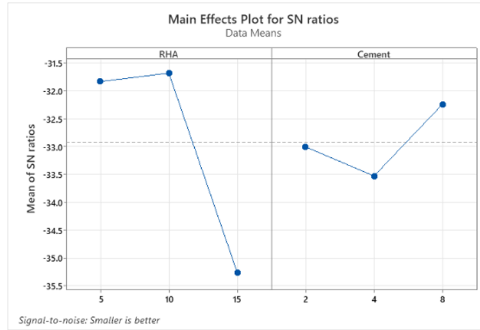
Fig 2. Liquid Limit (a) Normal Probability plot, (b) Versus Fits, (c) Versus orders

The regression analysis plots depicted in Figure 2 illustrate the residuals of a model used for predicting the liquid limit of soil. The Normal Probability plot in Fig. 2(a) demonstrates a strong correspondence when the residuals closely resemble the normal distribution. However, since the residuals do not exhibit an exact random distribution around the zero line, the Versus Fits Plot in Fig. 2 (b) indicates the presence of unexplained variability. Ultimately, the absence of noticeable patterns across time in the Versus Order Plot in Fig. 2 (c) indicates that the model is not influenced by time-related biases. Overall, these data indicate a predominantly successful model with minor, unexplained swings

4 Plastic limit



(a)



(b)

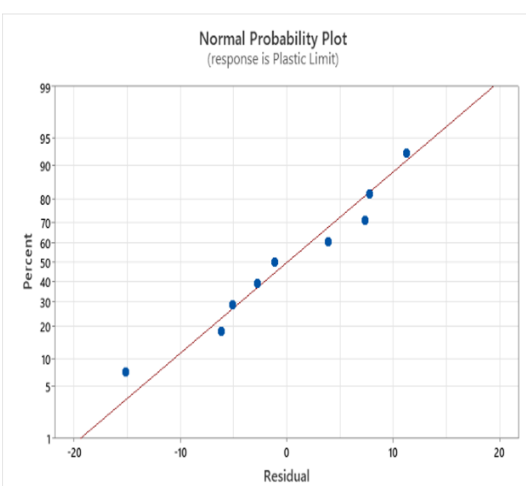
Fig 3. Plots for means and S/N ratio for plastic limit (a) main effect plot of RHA and cement for means (b) main Effect plot of RHA and cement for signal to noise ratio

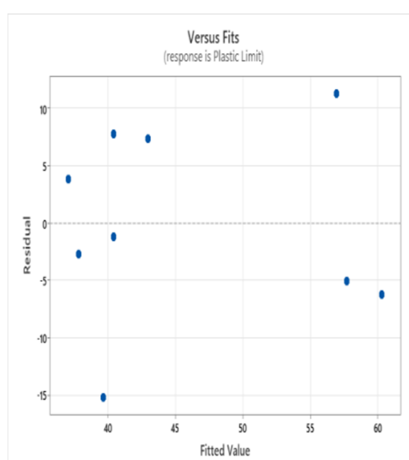
This study investigates the effects of RHA and cement on signal-to-noise (S/N) ratios for plastic limit. The first plot in Fig. 4(a) demonstrates that the values of RHA is low for 10%, then rises at 15%. The RHA trend in the second plot in Fig. 4(b) shows that, with greater percentages indicating a positive correlation. While cement improves S/N ratios and then falls, the data indicate that there is an optimal amount of cement for reducing atterberg limits. This suggests that optimum quantities of RHA and cement generally result in lower atterberg limits and quality outcomes[31-33].

4.1 Regression Equation

In this model, the constant term 45.94 serves as the baseline plastic limit. The coefficients associated with RHA_5, RHA_10, RHA_15, Cement_2, Cement_4, and Cement_8 (e.g, -4.90 for RHA_5, -7.48 for RHA_10, etc.) indicate the influence of each component on the plastic limit. Negative coefficients (e.g., for RHA_5, RHA_10, Cement_2, Cement_8) imply a reduction in the plastic limit with increasing amounts of that component, while positive coefficients (e.g., for RHA_15, Cement_4) suggest an increase in the plastic limit.

$$\text{Plastic Limit} = 45.94 - 4.90\ \text{RHA\_5} - 7.48\ \text{RHA\_10} + 12.38\ \text{RHA\_15} - 0.60\ \text{Cement\_2} + 1.96\ \text{Cement\_4} - 1.37\ \text{Cement\_8}$$

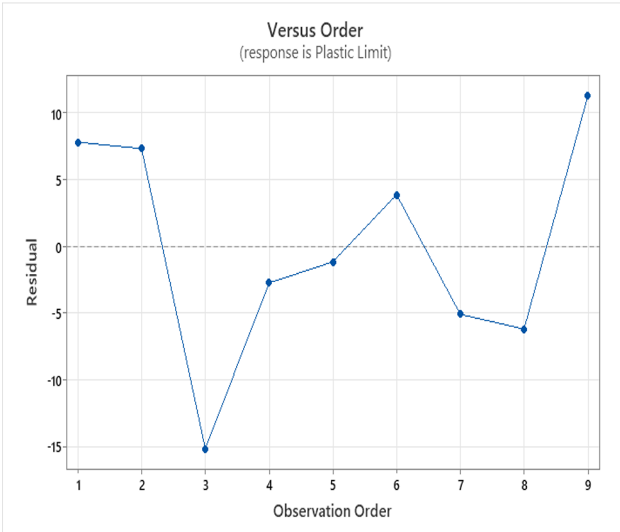




(b)

 https://doi.org/10.1051/e3sconf/202452901015

(a)

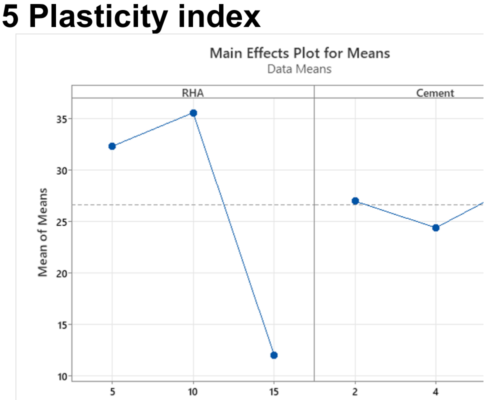


(c)

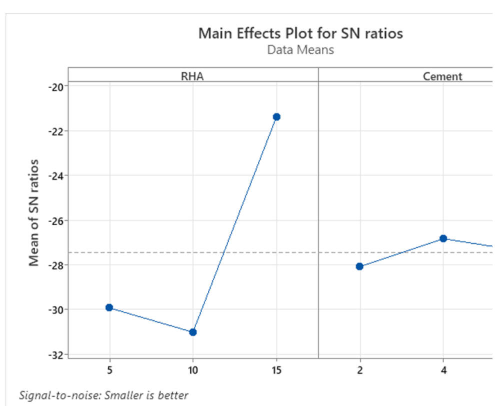
Fig 4. Plastic Limit (a) Normality plot, (b) Versus Fits, (c) Versus orders

The regression analysis plots depicted in Figure 2 illustrate the residuals of a model used for predicting the plastic limit of soil. The Normal Probability plot in Fig. 4(a) demonstrates a strong correspondence when the residuals closely resemble the normal distribution. However, since the residuals do not exhibit an exact random distribution around the zero line, the Versus Fits Plot in Fig. 4 (b) indicates the presence of unexplained variability. Ultimately, the absence of noticeable patterns across time in the Versus Order Plot in Fig. 4 (c) indicates that the model is not influenced by time-related biases. Overall, these data indicate a predominantly successful model with minor, unexplained swings.

5 Plasticity index



(a)



(b)

 https://doi.org/10.1051/e3sconf/202452901015

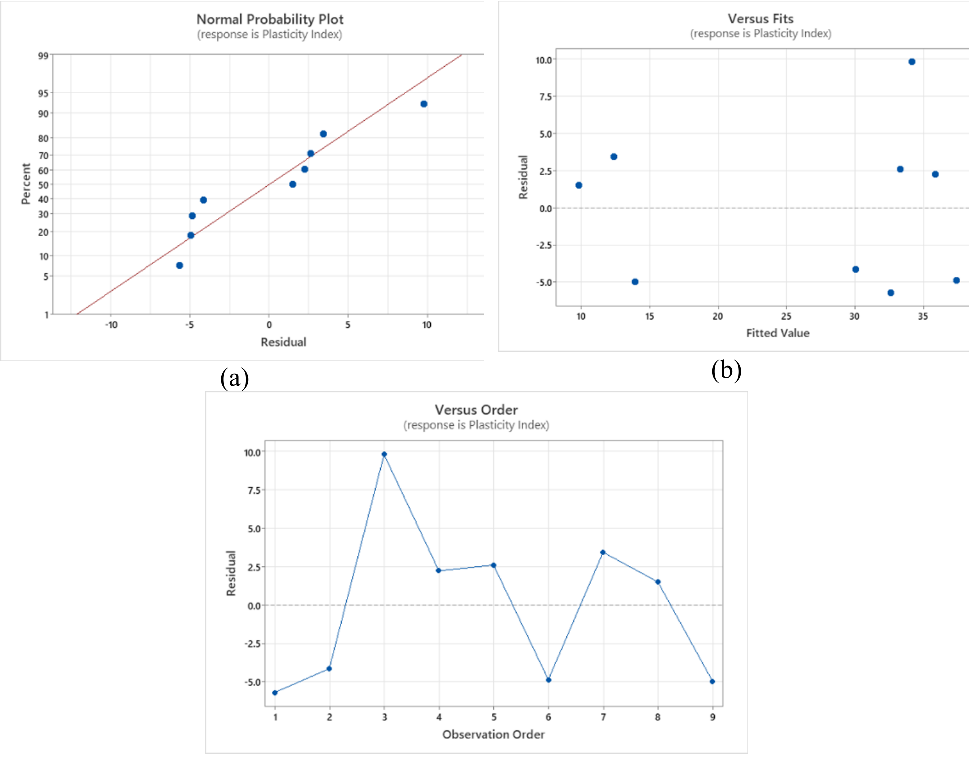
Fig 5. Plots for means and S/N ratio for plasticity index (a) main effect plot of RHA and cement for means (b) main Effect plot of RHA and cement for signal to noise ratio

This study investigates the effects of RHA and cement on signal-to-noise (S/N) ratios for plastic limit. The first plot in Fig. 5 (a) demonstrates that the values of RHA is high for 10%, then falls at 15%. The RHA trend in the second plot in Fig. 5 (b) shows that, with greater percentages indicating a positive correlation. While cement improves S/N ratios and then falls, the data indicate that there is an optimal amount of cement for reducing atterberg limits. This suggests that optimum quantities of RHA and cement generally result in lower atterberg limits and quality outcomes

5.1 Regression Equation

The equation for the Plasticity Index defines a predictive model that estimates the plasticity index of a material as influenced by the addition of rice husk ash (RHA) and cement, with the subscript numbers indicating different percentages or conditions for these additives. The constant term, 26.63, represents the base plasticity index. The coefficients for RHA_5, RHA_10, RHA_15, Cement_2, Cement_4, and Cement_8 (e.g., 5.65 for RHA_5, 8.92 for RHA_10, etc.) reflect the impact of each specific additive on the plasticity index. Positive coefficients (e.g., for RHA_5, RHA_10, Cement_2, Cement_8) indicate that an increase in the amount of that component leads to a higher plasticity index, suggesting a more plastic material. Conversely, negative coefficients (e.g., for RHA_15, Cement_4) denote a decrease in the plasticity index with increasing amounts of the component, implying a less plastic material.

$$\text{Plasticity Index} = 26.63 + 5.65\ \text{RHA\_5} + 8.92\ \text{RHA\_10} - 14.57\ \text{RHA\_15} + 0.34\ \text{Cement\_2} - 2.24\ \text{Cement\_4} + 1.90\ \text{Cement\_8}$$



(a) (b)

(c)

 https://doi.org/10.1051/e3sconf/202452901015

Fig. 6. Plasticity index (a) Normal Probability plot, (b) Versus Fits, (c) Versus orders

The normal probability plot, is developed that helps in visualization of information by showing the data that has been sorted with an approximate representation to the means or medians of the associated order statistics. To ascertain whether a tiny sample of data is representative of a normal distribution [27]. Stated otherwise, this might claim that the process has a steady distribution if the plot results in a straight line. Therefore, it's a great way to find out the Process capabilities.
Normal Probability Plot suggests that the residuals from the soil plasticity index model are approximately normally distributed in Fig. 6(a) the Versus Fits Plot reveals there may be some unexplained variability in the model as shown in Fig. 6(b). As many statistical models assume that the residuals are independent of time order, the lack of patterns in the Versus Order Plot is a positive indication also depicted in Fig. 6 (c).

6 Conclusion

When treated to various combinations of Rice Husk Ash (RHA) and Cement, the experimental findings demonstrate considerable differences in soil plasticity properties, indicating that the interplay between these additions crucially effects soil behaviour. Significantly, tests showing larger RHA percentages—especially at 15%—when combined with higher cement concentrations (at 8%), have shown a discernible decline in the Plasticity Index. This result indicates a notable improvement in soil stability and suggests that the key to obtaining a more stable and less plastic soil—which is very desirable for construction and engineering applications—may be larger concentrations of both RHA and cement.
Soil Plasticity Properties and RHA-Cement Interplay

a. Experimental findings show significant differences in soil plasticity properties when RHA and cement are combined. Higher cement concentrations increase soil's plastic and liquid limits while maintaining RHA amount.
b. Greater cement concentrations improve soil's water retention and malleability.
c. The Plasticity Index, a measure of soil's deformability, is uneven, suggesting a complex relationship between cement and soil plasticity. Larger RHA percentages and higher cement concentrations improve soil stability, suggesting larger RHA and cement concentrations are key to achieving stable, less plastic soil.

References

1. Francis, I. A., & Venantus, A. (2013). Models and optimization of rice husk ash-clay soil stabilization. Journal of Civil Engineering and Architecture, 7(10), 1260.
2. Trivedi, J. S., Nair, S., & Iyyunni, C. (2013). Optimum utilization of fly ash for stabilization of sub-grade soil using genetic algorithm. Procedia Engineering, 51, 250-258.
3. Trivedi, J. S., Nair, S., & Iyyunni, C. (2013). Optimum utilization of fly ash for stabilization of sub-grade soil using genetic algorithm. Procedia Engineering, 51, 250-258.
4. Ramprasad, Pikkili, Ch Basavapoornima, Shobha Rani Depuru, and C. K. Jayasankar. "Spectral investigations of Nd3+: Ba (PO3) 2+ La2O3 glasses for infrared laser gain media applications." Optical Materials 129 (2022): 112482.
5. Yoobanpot, Naphol, and Pitthaya Jamsawang. "Effect of cement replacement by rice husk ash on soft soil stabilization." Agriculture and Natural Resources 48.2 (2014): 323-332.

6. Buyondo, K. A., Olupot, P. W., Kirabira, J. B., & Yusuf, A. A. (2020). Optimization of production parameters for rice husk ash-based geopolymer cement using response surface methodology. Case Studies in Construction Materials, 13, e00461.
7. Liu, Y., Chang, C. W., Namdar, A., She, Y., Lin, C. H., Yuan, X., & Yang, Q. "Stabilization of expansive soil using cementing material from rice husk ash and calcium carbide residue." Construction and Building Materials 221 (2019): 1-11.
8. Alkorbi, A. S., Kumar, K. Y., Prashanth, M. K., Parashuram, L., Abate, A., Alharti, F. A., ... & Raghu, M. S. (2022). Samarium vanadate affixed sulfur self doped g-C3N4 heterojunction; photocatalytic, photoelectrocatalytic hydrogen evolution and dye degradation. International Journal of Hydrogen Energy, 47(26), 12988-13003.
9. Patro, Sudhansu, Kuldeep Kumar Saxena, and Ajit Behera. "Effect of Annealing Temperature and Thickness of Magnetron Sputtered Ni/Ti Film on Its Microstructure and Nanoindentation Behavior." Metal Science and Heat Treatment 65, 3 (2023): 167-172.
10. Basha, E. A., Hashim, R., Mahmud, H. B., & Muntohar, A. S. (2005). Stabilization of residual soil with rice husk ash and cement. Construction and building materials, 19(6), 448-453.
11. Swarna, K. S. V., Vinayagam, A., Ananth, M. B. J., Kumar, P. V., Veerasamy, V., & Radhakrishnan, P. (2022). A KNN based random subspace ensemble classifier for detection and discrimination of high impedance fault in PV integrated power network. Measurement, 187, 110333.
12. Ghorbani, Ali, and Meysam Salimzadehshooiili. "Evaluation of strength behaviour of cement-RHA stabilized and polypropylene fiber reinforced clay-sand mixtures." Civil Eng J 4 (2018): 2628-41.
13. Ghorbani, Ali, and Maysam Salimzadehshooiili. "Dynamic characterization of sand stabilized with cement and RHA and reinforced with polypropylene fiber." Journal of Materials in Civil Engineering 31.7 (2019): 04019095.
14. Adeyanju, E., Okeke, C. A., Akinwumi, I., & Busari, A. "Subgrade stabilization using rice husk ash-based geopolymer (GRHA) and cement kiln dust (CKD)." Case Studies in Construction Materials 13 (2020): e00388.
15. Sharma, Sachin Kumar, and Kuldeep Kumar Saxena. "A brief overview of HA on the mechanical behavior of MMCs." In AIP Conference Proceedings, vol. 2721, no. 1. AIP Publishing, 2023.
16. Manohar, T., Prashantha, S. C., Nagaswarupa, H. P., Naik, R., Nagabhushana, H., Anantharaju, K. S., ... & Premkumar, H. B. (2017). White light emitting lanthanum aluminate nanophosphor: near ultra violet excited photoluminescence and photometric characteristics. Journal of Luminescence, 190, 279-288.
17. Khudair, Zainab Falah, Zainab Ahmed Abass, Karrar Hazim Salem, Kahtan A. Mohammed, Rahman S. Zabibah, Mohammed Ayad Alkhafaji, and Kuldeep K. Saxena. "Wavelength Role in Synthesis and Study of the Structure of Silver Nanoparticles Prepared by Pulsing Laser Ablation in Liquid." International Journal of Nanoscience 22, no. 04 (2023): 2350032.
18. Srinivasan, K., Porkumaran, K., & Sainarayanan, G. (2009, August). Improved background subtraction techniques for security in video applications. In 2009 3rd International Conference on Anti-counterfeiting, Security, and Identification in Communication (pp. 114-117). IEEE.
19. Paul, Abhinaba, and Monowar Hussain. "Sustainable Use of GGBS and RHA as a Partial Replacement of Cement in the Stabilization of Indian Peat." International Journal of Geosynthetics and Ground Engineering 6 (2020): 1-15.
20. Musa, Alhassan, and Mustapha Mohammed Alhaji. "Effect of rice husk ash on cement stabilized laterite." (2007).

21. Arun, V., Singh, A. K., Shukla, N. K., & Tripathi, D. K. (2016). Design and performance analysis of SOA–MZI based reversible toffoli and irreversible AND logic gates in a single photonic circuit. Optical and quantum electronics, 48, 1-15.
22. Ashwini, S., Prashantha, S. C., Naik, R., & Nagabhushana, H. (2019). Enhancement of luminescence intensity and spectroscopic analysis of Eu3+ activated and Li+ charge-compensated Bi2O3 nanophosphors for solid-state lighting. Journal of Rare Earths, 37(4), 356-364.
23. Eliaslankaran, Z., Daud, N. N. N., Yusoff, Z. M., & Rostami, V. "Evaluation of the effects of cement and lime with rice husk ash as an additive on strength behavior of coastal soil." Materials 14.5 (2021): 1140.
24. Reddy, P. Venkateshwar, B. Veerabhadra Reddy, and P. Srinivasa Rao. "A numerical study on tube hydroforming process to optimize the process parameters by Taguchi method." Materials Today: Proceedings 5.11 (2018): 25376-25381.
25. Arun, V., Shukla, N. K., Singh, A. K., & Upadhyay, K. K. (2015, September). Design of all optical line selector based on SOA for data communication. In Proceedings of the Sixth International Conference on Computer and Communication Technology 2015 (pp. 281-285).
26. Awasthi, Ankita, Kuldeep K. Saxena, R. K. Dwivedi, Dharam Buddhi, and Kahtan A. Mohammed. "Design and analysis of ECAP Processing for Al6061 Alloy: a microstructure and mechanical property study." International Journal on Interactive Design and Manufacturing (IJIDeM) 17, 5 (2023): 2309-2321.
27. Kumar, C. P., Raghu, M. S., Prathibha, B. S., Prashanth, M. K., Kanthimathi, G., Kumar, K. Y., ... & Alharthi, F. A. (2021). Discovery of a novel series of substituted quinolines acting as anticancer agents and selective EGFR blocker: Molecular docking study. Bioorganic & Medicinal Chemistry Letters, 44, 128118.
28. Adeyanju, E., Okeke, C. A., Akinwumi, I., & Busari, A. (2020). Subgrade stabilization using rice husk ash-based geopolymer (GRHA) and cement kiln dust (CKD). Case Studies in Construction Materials, 13, e00388.
29. Shukla, Ashish, Nakul Gupta, Nanna Sri Ramya, Kuldeep K. Saxena, Amjad Iqbal, and Faramarz Djavanroodi. "Environmental sustainability in construction: Influence of Megaterium Bacteria on the durability and mechanical properties of concrete incorporating calcined clay." Mechanics of Advanced Materials and Structures (2023): 1-13.
30. Chen, K., Wu, D., Zhang, Z., Pan, C., Shen, X., Xia, L., & Zang, J. (2022). Modeling and optimization of fly ash–slag-based geopolymer using response surface method and its application in soft soil stabilization. Construction and Building Materials, 315, 125723.
31. Arunkumar, K., Muthukannan, M., Dinesh Babu, A., Hariharan, A. L., & Muthuramalingam, T. (2020). Effect on addition of Polypropylene fibers in wood ash-fly ash based geopolymer concrete. *IOP Conference Series: Materials Science and Engineering*, *872*(1). https://doi.org/10.1088/1757-899X/872/1/012162
32. Arunvivek, G. K., & Rameshkumar, D. (2019). Experimental Investigation on Performance of Waste Cement Sludge and Silica Fume-Incorporated Portland Cement Concrete. *Journal of The Institution of Engineers (India): Series A*, *100*(4), 611–618. https://doi.org/10.1007/s40030-019-00399-3
33. Sankar, B., & Ramadoss, P. (2022). *Mechanical and Durability Properties of High Strength Concrete Incorporating Different Combinations of Supplementary Cementitious Materials: A Review*. https://doi.org/10.1007/978-981-16-4321-7_45