International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-10, Issue-2, April 2023
https://doi.org/10.55524/ijirem.2023.10.2.11
Article ID IJIRD-1239, Pages 60-64
www.ijirem.org

Use of Rice Husk Ash to Stabilize Subgrade Soil

Vijay Kumar Singla

M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Vijay Kumar Singla; singla.vijay1678@gmail.com

ABSTRACT- Significant gains are predicted as a result of the study because the stabilisation of soil using industrial wastes has emerged as a serious issue in building engineering. The current experimental work provides a clear rationale for the acceptability of using the locally available Rice Husk Ash (RHA) in the construction industry in order to reduce the volume of waste that must be disposed of to the environment, causing environmental contamination. Because stabilising materials like cement and lime are becoming more expensive, popular ground restoration methods are becoming more expensive. By substituting RHA for a sizeable amount of the stabilising agent, the cost of stabilisation could be reduced. Risks to the environment will also be decreased. This study investigates the stability and compaction of stabilised soil.

KEYWORDS- Ash, Soil, Environment, Industry.

I. INTRODUCTION

When soil is stabilised, it is done so in a manner that maintains, improves, or otherwise modifies how it functions as a building material for roadways. Both the mechanical blending of various soil types and the use of chemicals alter the properties of the soil. Soil stabilisation is the process of modifying a soil's properties to boost its tensile strength and durability. "Soil stabilisation" refers to any physical, chemical, biological, or combination of methods used to alter a natural soil to support an engineering goal. Soil stabilisation can be employed on highways, parking lots, site development projects, airports, and many other sites when subsoils are unsuitable for constructing roadways. Stabilization is a treatment method for several conditions. A range of sub-grade materials, including expanding clays and granular materials, can be treated using stabilisation procedures [1-5].

Only a few of the components needed for this process include fly ash, lime, and Portland cement. Other by-products of the materials used in stabilisation include cement kiln dust and lime kiln dust (LKD) (CKD). Civil engineering projects located in areas with soft or poor soils have historically used a variety of strategies to improve the soil's quality.

Cement and lime are the two main ingredients frequently used to stabilise soil. Due to the sudden rise in energy prices, the cost of these commodities has increased quickly. As a result, incorporating agricultural waste in building will cut down on expenses and environmental hazards like rice husk ash (RHA). Rice husk is a by-product of the milling of rice. Annual production of rice husk is 108 tonnes worldwide. Increasing a soil's shear strength and total bearing capacity is necessary for stabilising it. After stabilisation, the construction of a solid monolith reduces permeability, minimising the likelihood of contraction and expansion as well as the harmful effects of freeze-thaw cycles. Shrink/swell potential describes a soil's capacity to shrink or swell in response to variations in moisture content. With an expansion capability of up to 10%, some expansive soils can easily produce enough force to seriously damage a house, building, or road [6].

By using soil stabilisation, it is possible to enhance in-situ, or natural state, soils without having to do costly remove-and-replace procedures. Roadbed, construction pad, and parking lot foundation soils are typically chemically treated. Usually, waste is dumped straight into open spaces and waterways, which disturbs the ecosystem and causes pollution [7]. As a result, garbage disposal has grown into a severe environmental issue that needs to be addressed right away. Using these wastes in the construction industry is one strategy.

A. Importance and Effect of Soil Stabilization on Structures

Stabilized soils provide a stable working surface for all other project components. The formation of long-lasting pozzolanic reactions after stabilising methods can change weak soils. indicating that soils are substantially less permeable and less prone to leaching, which reduces the possibility of shrinkage and expansion and increases resistance to freeze-thaw cycles. Even yet, several changes have been made to stabilised soils. To put it another way, the soil has changed physically, which reduces flexibility and simplifies compaction. Compaction is made simpler, making it easier to reach the maximum dry density. The crucial water content of soils is taken into consideration by the significant geotechnical parameter known as the plasticity index. When the soil flexibility decreases, the soils become more friable and workable.

B. Purpose of Soil-Stabilization

- To reinforce bases, sub-bases, and sporadically surface courses, as with low-cost roads.
- To reduce or eliminate a number of unwanted characteristics of soils, such as excessive swelling or shrinkage, high plasticity, challenging compacting, etc.
- To boost compaction and load-bearing capacity
- To reduce settling and consequently, compressibility.
- To improve permeability characteristics.
- To make building roads more affordable.

II. LITERATURE REVIEW

Roy [8] looked examined how RHA affected the optimal moisture content (OMC), maximum dry density (MDD), and California bearing ratio (CBR) of soil in a number of studies. The results show an increase in OMC, a decrease in MDD, and a rise in CBR. These results show that 10% rice husk ash and 6% cement have the greatest effects on improving the target soil properties. The effectiveness and affordability of this method of soil stabilisation make it highly recommended [8]. The RD content boosted the strength of the soil grouting by filling the pores. Unconfined compression test (UCS) has maximum values in RD by (15%) with PC having (85%) and during cement hydration it may undergo the consumption of Ca(OH)2 [9]. Moreover, the UCS value grew when the curing time was extended beyond the initial 0, 7, and 14 days. A multi linear regression analysis (MLRA) was performed on the results of the UCS tests, and the matching equation was developed. The strongest mixture, in terms of strength, was discovered to comprise 75% CS, 20% RHA, and 5% C [10]. In order to encourage proper bonding between RHA and the soil, lime was added to Clayey Sand for Lakshmi et al investigations. The optimal amount of admixture for Clayey Sand, with the highest UCS (Unconfined Compression Stress) test and soaking CBR strength after 3 days of curing, was found to be 4% lime with 20% RHA based on the test findings [11].

A cheap and ecologically friendly cement can be made by mixing an alkaline activator with mining or industrial waste as the binder ingredient. Because geo polymeric binder is a byproduct of the inorganic poly condensation reaction known as geo polymerization, aluminum silicate binder from industrial or mining waste is referred to as an inorganic geopolymeric compound. Alkaline ions, a type of positive ion, are needed to counteract the negative alumina ions. Because it might boost the soil's shear strength and cut costs, fly ash from the combustion of coal has been utilised to stabilise soil embankments. Actually, the application of 20% geopolymer in soil embankment stabilisation yielded the greatest results, according to the California Bearing Ratio (CBR) test evaluation. Also, the UCS (Unconfined Compression Stress) test findings showed that the usage of 20% geopolymer in peat soil generated the greatest outcomes. Yet, by adding 10%, 30%, or 50% additional lime or cement, peat soil's soil carrying capacity was regularly increased [3, 12].

Table 1: RHA materials through soil stabilization

Author (s)	Additives	Results
Maity et al. [13]	0%, 2%, 4%, 6%, and 8% for RHA and 2%, 4%, 6%, and 8% for OPC.	OMC rose while MDD fell as RHA concentration rose. RHA and OPC were included, which improved the UCS and CBR values.
Sharma and Sharma [14]	RHA and C&D waste with or without lime in clayey soil	RHA increased the soil's OMC while decreasing its MDD. The CBR value was enhanced by RHA (12%) and Lime (5%).
Gupta et al. [15]	Marine clay, RHA, gypsum and lime	In both drenched and unsoaked settings, the MDD improves as the RHA concentration rises, and the addition of 3% gypsum produces even better results. In contrast, the OMC falls down when the RHA concentration rises in both drenched and unsoaked situations. When 9% lime is added, the OMC falls off even more, by 42.63%.
Onyelowe et al. [16]	RHA and clayey soil	The swelling potential of the treated expansive soil was improved by lowering the permissible standard limits, which have a range from 0 to 12.6% for a compacted soil material that is to be used as subgrade material for pavement. These compositions include quicklime-activated rice husk ash (QARHA), hydrated lime-activated rice husk ash (HARHA), and calcite-activated rice husk ash (CARHA).
Eliaslankaran et al [17]	Cement, lime, RHA and coastal soil	8% lime is present in the soil combination. The soil combination comprising 8% lime and a 1:2 ratio of rice husk ash (LRHA) demonstrated competitive and comparatively equal strength capabilities, including shear strength and cohesiveness, when compared to samples that had been treated with cement mixture. For treating coastal soil, it is strongly advised to use cement rather than lime.

III. EXPERIMENTATION PROGRAMME

A. Materials

i. Soil

The disturbed sampling method was used to collect a soil sample for this inquiry from a local area in Bathinda Punjab, India, at a depth of 1.5 to 2.5 metres. Table 2 lists the characteristics of the soil that was used in the experiment. The classification of the soil consists of overall geotechnical properties.

ii. Rice Husk Ash (RHA)

The Parshotam Lal Rice Mill in Bathinda provided the RHA. Before usage, the RHA was powdered and sieved through a 0.075 mm aperture. Table 3 displays the RHA's oxide composition.

Table 2: Characteristics of natural soil

Sr.	Characteristics	Description
1	Optimum moisture content (%)	11.2
2	Maximum dry density (MDD), g/cc	2.02
3	Specific gravity	2.50
4	Type of Soil	Poorly-graded sands
5	Liquid limit (%)	18.85
6	Plastic limit (%)	0
7	Gravel (> 4.750mm) %	0
8	Sand (0.75-4.750mm) %	100

Table 3: Oxide composition of RHA

Sr.	Constituent
1	SiO_2
2	Al_2O_3
3	Fe_2O_3
4	CaO
5	MgO
6	Loss on Ignition

Figure 1: Rice Husk Ash

iii. Cement

Throughout the experiment, ordinary Portland cement (OPC) that complies with IS 8112-1989 has been used. The following list confirms the physical characteristics of cement according to IS code. The tests on the cement samples were all conducted in accordance with the guidelines of IS 4031:1988. Table 4 lists the characteristics of the cement utilised in the experiment, and Table 5 lists the material's description.

Table 4: Physicals properties of the Cement

Sr.	Tests	Results
a.	Initial setting time	35 Minutes
b.	Final setting time	600 Minutes
c.	Fineness of cement (%)	6.3
d.	Specific Gravity	3.16

Table 5: Material Description

Sr. No	Material	Make
1	Soil	Poorly-graded sands (Locally Available)
2	Rice Husk Ash	Parshotam Lal Rice Mills
3	Cement	Ordinary Portland Cement (OPC)-43
4	Water	Fresh Water

IV. RESULTS AND DISCUSSIONS

A. RHA Waste and Cement as Partial Replacement

Table 6: Details of Replacement by soil by Ash made from rice husks and cement

Sr No	Denotation	Soil	Rise Husk Ash	Cement
1	S-0	100%	0%	0%
2	S-5	93%	5%	2%
3	S-10	88%	10%	2%
4	S-15	83%	15%	2%

B. Compaction Characteristics

Figures 2 show the fluctuations of MDD and OMC with RHA contents along with soil and 2% cement, respectively. The MDD decreases and the OMC increases when RHA content increases.

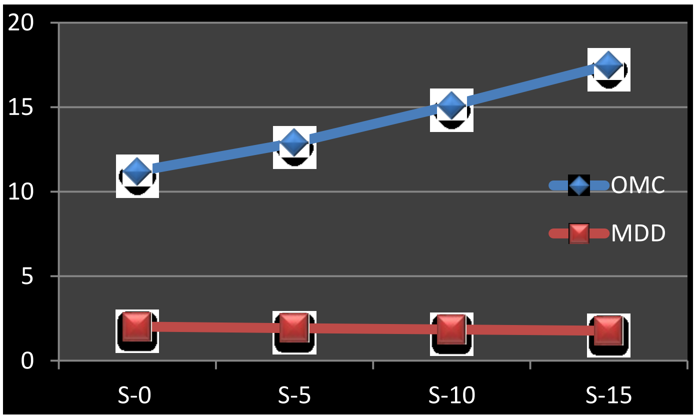

Figure 2: OMC and MDD Variation with RHA Content

C. California Bearing Ratio

i. Un-soaked Test

The California bearing ratio is the preferred and most flexible approach for evaluating the stability of stabilised soil (CBR). It is the primary test that is suggested for determining the quantity of additive needed to stabilise the soil. Figure 3 illustrates research on the effects of raising RHA from 10% to 15% while utilising 2% cement on CBR fluctuations. When cement concentration is 2% and RHA content is 10%, the CBR rises by 22.99%. Additionally, the value of CBR is greatly diminished by a 15% RHA with a 2% cement component.

The CBR values rise with each further addition of RHA until they reach their maximum at 10% RHA, at which point they begin to decline. The subsequent rise in CBR is ascribed to the cementitious compounds that form between the pozzolans and CaOH in the RHA and the soil. The decrease in CBR values after the addition of 10% RHA with 2% cement may be due to the excess RHA injected into the soil and the ensuing creation of weak connections between the soil and the cementitious compounds formed.

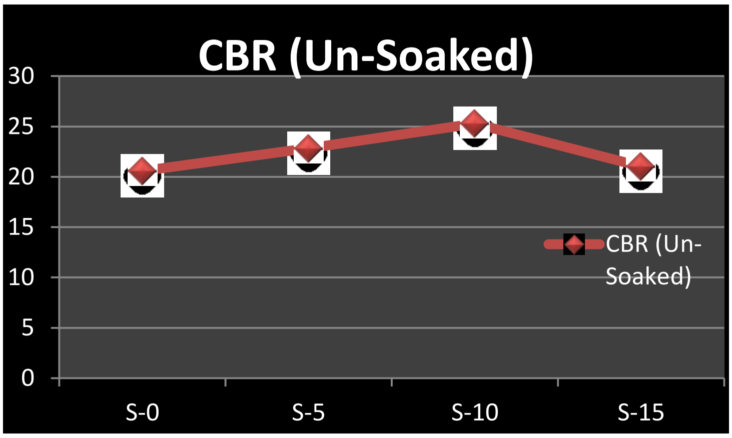

Figure 3: Variation in Un-Soaked CBR with RHA Content

ii. Soaked Test

Figure 4 illustrates the results of an inquiry into the changes of CBR with an increase in RHA from 10% to 15% with 2% cement. When RHA concentration is 10% with 2% in cement, CBR rises by 87.98%. Also, a 15% RHA percentage drastically lowers CBR's value.

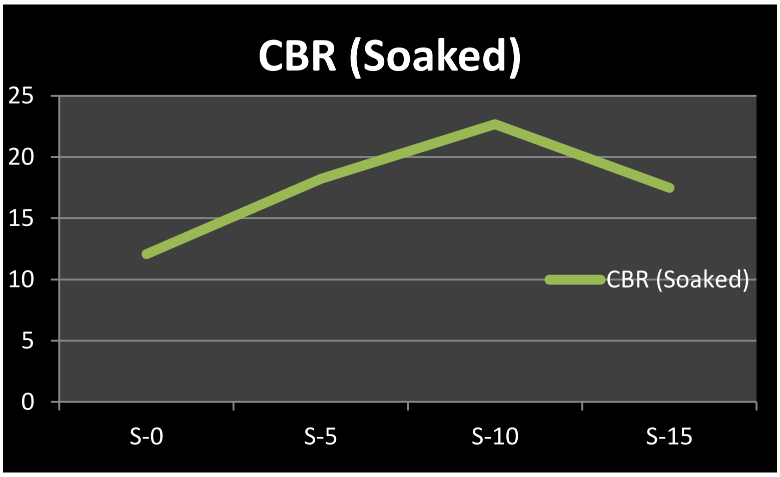

Figure 4: Variation in Soaked CBR with RHA Content

V. CONCLUSION

Using this research's findings, the following conclusions are drawn:

- When RHA is employed in combinations with a little amount of cement, the optimal moisture content frequently rises and the maximum dry density frequently decreases.
- In addition, the CBR of the unsoaked soil is higher than that of untreated soil (22.9% at 10% RHA with 2% cement content).
- The soil's CBR after being saturated (87.98 at 10% RHA with 2% cement content) is higher than the CBR of the un-soaked soil sample, which shows a similar trend.
- The ideal amount for practical applications is suggested as soil stabilised with 10% RHA content and 2% cement for greatest boost in strength.
- By using RHA more frequently, we can sort out the waste issue.
-

REFERENCES

[1] A. Pedarla, S. Chittoori, and A. J. Puppala, "Influence of mineralogy and plasticity index on the stabilization effectiveness of expansive clays," Transportation Research Record: Journal of the Transportation Research Board, vol. 2212, no. 1, pp. 91–99, 2011.

[2] B. C. S. Chittoori, D. Mishra, and K. M. Islam, "Forensic investigations into recurrent pavement heave from underlyingexpansive soil deposits," Transportation Research Record: Journal of the Transportation Research Board, vol. 2672, no. 52, pp. 118–128, 2018.

[3] Nasuhi Zn et.al. "Resilint Modulus Characteristics of Soil Subgrade with Geopolymer Additive in Peat" AIP Conference Proceedings 1855, 030006, 2017.

[4] Mayank Pathak, Vinod Kumar Sharma, Rajiv Kumar, Gagandeep Singh, Ashish Pratap Singh, Mahesh Patel, "A Review of Soil Stabilization Using Resilient Modulus", Structural Integrity ASMA proceeding Springer Nature Switzerland AG, pp. 155-161 (July, 2022) http://dx.doi.org/10.1007/978-3-031-05509-6_12

[5] Ashish Pratap Singh, Mayank Pathak, Rajiv Kumar, Kanish Kapoor, "Studies on the Design of Flexible Pavement Using Resilient Modulus: A Review", Optimization of Industrial

System: Application and Processes, Wiley, pp. 101-110 (July, 2022) https://doi.org/10.1002/9781119755074.ch8

[6] Francis Achampong, Mumtaz Usmen, And Takaaki Kagawa "Evaluation of Resilient Modulus for Lime- and Cement-Stabilized Synthetic Cohesive Soils" Transportation Research Record 1589, 2019.

[7] Karthik.S, Ashok kumar.E, Gowtham.P , Elango.G, Gokul.D, Thangaraj.S., Soil Stabilization By Using Fly Ash. IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), Vol. 10, Issue 6, PP 20-26, (2014)

[8] Roy, A., Soil Stabilization using Rice Husk Ash and Cement. International Journal of Civil Engineering Research, Vol. 5, pp. 49-54, (2014)

[9] Çelik S., An experimental investigation of utilizing waste red mud in soil grouting. KSCE Journal of Civil Engineering, vol. 21, pp.1191-1200, (2017)

[10] Sharma R K. (2020), Utilization of fly ash and waste ceramic in improving characteristics of clayey soil: A Laboratory Study. Geotechnical and Geological Engineering, vol. 38, pp. 5327-5340.

[11] Muthu Lakshmi S., Geetha S., Selvakumar M., Divya Susanna K. (2021), Strength enhancement of Clayey Sand subgrade using lime and rice husk ash, materialtoday proceeding, Volume 46, Part 17, 2021, Pages 7430-7435. https://doi.org/10.1016/j.matpr.2021.01.039

[12] C. A. U. Okeke, "Engineering behaviour of lime- and waste ceramic dust-stabilized expansive soil under continuousaching," Bulletin of Engineering Geology and the Environment, pp. 1–17, 2019.

[13] Maity J, Chattopadhyay BC, Mukherjee SP., Improvement of Characteristics of Clayey Soil Mixed with Randomly Distributed Natural Fibers. Journal of The Institution of Engineers (India); Series A vol.99, pp. 55-65, (2017)

[14] Sharma A, Sharma RK., Subgrade characteristics of soil stabilized with agricultural waste, constructional waste, and lime. Bulletin of Engineering Geology and the Environment, 2020.

[15] Gupta M.A, Goyal A.S, Anaokar M.R., Soil stabilization using Waste rice husk ash, cement, lime&gypsum. International Civil Engineering Symposium (2014)

[16] Kennedy CO, Michael EO, Diu NT, Duc BV, Eze O, Haci B, Ifeoma IO, Lam DP, Hyginus UU., High-Performance Materials and Advanced Characterization Methods for Durable Pavement. advances in Materials Science and Engineering, vol. 2021, (2021) https://doi.org/10.1155/2021/6688519

[17] 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, vol. 14, (2021) https://doi.org/10.3390/ma14051140