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Comparative study of compaction characteristics of Shyorana village soil, Bharatpur using red stone dust and eggshell powder

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ABSTRACT

Soil stabilization is a crucial technique in civil engineering to enhance the mechanical properties of soil for construction purposes. This study investigates the potential of utilizing red stone dust and eggshell waste as additives for analysis of compaction characteristics of Shyorana village soil in district Bharatpur Rajasthan. Red stone dust, a byproduct of stone crushing activities, and eggshell waste, generated from culinary and food processing industries, both pose environmental challenges in terms of disposal. This research aims to address these challenges by assessing their effectiveness as stabilizing agents while promoting sustainability.

Laboratory experiments were conducted to evaluate the impact of varying proportions of red stone dust and eggshell on soil properties. Standard proctor tests were performed on soil samples treated with different combinations of red stone dust and eggshell. The results were compared with untreated soil to determine the improvements in dry density.

The findings demonstrated that the incorporation of red stone dust led to increased compaction indicating enhanced load-bearing capacity and reduced susceptibility to deformation. Moreover, the combination of red stone dust and eggshell exhibited synergistic effects, further enhancing the overall stabilization efficiency.

In addition to the technical performance, environmental considerations were also addressed. The utilization of waste materials like red stone dust and eggshell offers a sustainable solution by minimizing their disposal as waste and reducing the demand for conventional stabilizing agents. This approach aligns with the principles of circular economy and promotes eco-friendly construction practices.

Keywords: *Shyorana village soil, compaction, red stone dust, egg shell*

1. INTRODUCTION

Compaction is a fundamental geotechnical process that plays a pivotal role in determining the engineering properties and behavior of soils. The compaction characteristics of soil are essential in various civil engineering applications, including foundation design, road construction, and embankment construction. Understanding the compaction behavior of soil is crucial for ensuring the stability, load-bearing capacity, and durability of constructed structures.

This study focuses on investigating the compaction characteristics of the soil in Shyorana village. Shyorana village, located in [Bharatpur, Rajasthan], represents a unique soil composition influenced by its geological history, climate, and land use patterns. The compaction behavior of this soil is of particular interest due to its potential implications for local infrastructure development and environmental sustainability.

The compaction process involves the densification of soil particles by applying mechanical energy through compaction equipment. Murmu Lal Anant et al. [1] showed the practicability of using fly ash & geo-polymer to stabilize black cotton soil. Gullu Hamza and Girisken serkan [2] performed the experimental study on cohesive soil treated with industrial wastewater sludge. Karkush Mahdi et al. Fattah, Joni and Dulaimy [3] results shows increase in CBR from 443% to 707% in 2.54mm penetration and 345% to 410% in 5.08mm penetration. Aflaki and Hajiannia [4] Study shows high UCS and tri-axial compressive strength value of sand amended with oil residue. Seif and El-Khashab [5] Chemically sand dunes are free from any chemical active chert, flint, chalcedony and dolomite grains. Rammal and Jubair [6] stated that sand dunes shear strength and cohesion increased by 74% and 150% respectively at age of 28 days and penetration decrease 66%. Baghdadi and Rahman [7] investigated as the amount of CKD increased then both compressive strength & CBR value increased. It is good alternative of cement or lime in soil stabilization for road bases and sub bases.

Saxena [8] Studied that porcelain waste is used for the stabilized sand dunes. Value of direct shear test (ϕ) increase as increased size of porcelain waste particles. MDD increases as incrementing particle size of porcelain waste. Mahent and Joshi [9] concluded that use of local gravel soil in construction of road pavements layers by adding a fine percentage of stone dust because index properties and strength of such type gravel soil is low. Xia et. al[10] experimental study shows that sand have low bearing capacity to improve that geo-grid or replace weaker soil with the stones and Aeolian sand is used. Kumar et. al [11] stabilized sand dunes by adding LDPE waste strips which indicates that CBR values of the soil increased by 27% for unsoaked and 25% for soaked. The permeability of the soil is reduced up to 47%. Tiwari, Sharma and Yadav [12] perform an experimental Gaur gum gives better results compared to bentonite in reducing permeability of sand dunes. Sand dunes UCS significantly increased by treating sand with cement and lime but age of curing plays very important role in cement and lime. Li, Ma and Li [13] With increase of dune sand replacement ratio, the stirrup stain and ultimate strength of dsc beam decreased and damaged deflection increased. Elmashad [14] Cohesion strength is increased for sand by increasing ratio of all cohesive admixture from 4% to 20%, maximum increase in bentonite because of its high liquid limit and activity. Permeability of decreased slightly by all cohesive admixture, in this also maximum decreased by bentonite.

The key objective is to achieve a soil density that maximizes its shear strength, minimizes its permeability, and reduces its susceptibility to settlement. The compaction characteristics of a soil are influenced by various factors, including its particle size distribution, moisture content, compactive effort, and mineralogical composition.

In the case of Shyorana village soil, understanding its compaction behavior holds significance for several reasons:

- **Engineering Applications:** The compaction characteristics directly affect the stability and load-bearing capacity of foundations, embankments, and retaining structures in the region. Knowledge of these characteristics is vital for designing safe and resilient infrastructure.
- **Agricultural Implications:** The agricultural practices in the village could be influenced by the soil's compaction behavior, affecting water infiltration, root penetration, and overall crop productivity.
- **Environmental Considerations:** Soil compaction can impact natural drainage patterns and water retention, potentially contributing to soil erosion and runoff. Understanding these effects is essential for sustainable land use planning.
- **Construction Challenges:** The presence of specific minerals, organic matter, or other geological attributes can influence the soil's response to compaction efforts, leading to potential construction challenges that need to be addressed.

This study aims to comprehensively characterize the compaction behavior of Shyorana village soil through a series of laboratory compaction tests, including Standard Proctor and Modified Proctor tests. By evaluating the relationship between moisture content, compactive effort, and resulting dry density, the compaction curve for the soil can be established. This curve provides valuable insights into the soil's maximum dry density and optimum moisture content, which are critical parameters for construction projects.

Ultimately, a deeper understanding of the compaction characteristics of Shyorana village soil will contribute to informed decision-making in various engineering, agricultural, and environmental contexts. The results of this study can guide proper soil management practices, aid in designing resilient infrastructure, and promote sustainable land use planning for the benefit of the local community and the region at large.

2. EXPERIMENTAL PROGRAM

(i). Sample Collection and Preparation

A representative soil sample from Shyorana Village was collected for the study. The soil sample underwent air-drying to remove organic materials, debris, and larger particles. Aggregates were crushed to ensure uniformity of the soil. The collected soil served as the base material for the mixture.

(ii). Mixing of Red Stone Dust and Eggshell Powder

Red stone dust and eggshell powder were selected as additives for the soil mixture. The proportions of red stone dust and eggshell powder were determined based on weight percentages. The base soil and additives were thoroughly mixed to achieve a homogenous blend.

(iii). Determination of Moisture Content

Moisture content was determined for the mixed soil samples before compaction. A portion of each mixture was weighed and placed in an oven at 105°C for 24 hours. After drying, the samples were re-weighed to calculate the moisture content using the standard formula.

(iv). Compaction Testing

Standard Proctor Compaction Test was conducted on the mixed soil samples to assess their compaction characteristics. Samples with varying moisture contents were prepared for testing. The Proctor compaction mold was filled in layers, and each layer was compacted using a Proctor hammer with specified blows.

(v). Determination of Bulk Density and Dry Density

Following compaction, the samples were carefully removed from the mold. Their dimensions were measured, and the samples were weighed. Bulk density was calculated by dividing the wet mass of the sample by the volume of the mold. Dry density was then computed by dividing the bulk density by 1 plus the moisture content.

(vi). Data Analysis

Compaction curves were plotted for different mixtures, illustrating the relationship between moisture content and dry density. The maximum dry density and optimum moisture content for each mixture were determined from the curves. Statistical analysis techniques were employed to evaluate any significant differences between the compaction characteristics of the different mixtures.

To investigate the effect of red stone dust and egg shell powder on the characteristics of shyorana village soil the following tests are performed as present in Table 1.

Table 1. Experimental Tests performed in the Laboratory

Sr. No.	Experimental tests	Properties	IS code
1	Sieve Analysis	Grain size distribution & Soil Classification	IS: 2720 (Part 4) 1985 (15)
2	Standard Proctor test	OMC & MDD	IS: 2720 (Part 7) 1980 (16)

Table 2. Experimental Program for Shyorana village soil and Egg shell powder

Sr. No.	Mix designation	Description
1	SVS	Shyorana village soil
2	SVSE1	Shyorana village soil + 2.5% Egg shell powder
3	SVSE2	Shyorana village soil + 5.0% Egg shell powder
4	SVSE3	Shyorana village soil + 7.5% Egg shell powder
5	SVSE4	Shyorana village soil + 10.0% Egg shell powder

Table 3. Experimental Program for Shyorana village soil and Red stone dust

Sr. No.	Mix designation	Description
1	SVS	Shyorana village soil
2	SVSR1	Shyorana village soil + 2.0% Red stone dust
3	SVSR2	Shyorana village soil + 4.0% Red stone dust
4	SVSR3	Shyorana village soil + 6.0% Red stone dust
5	SVSR4	Shyorana village soil + 8.0% Red stone dust

3. RESULTS AND DISCUSSION

Sieve Analysis Test

For the determination of the Grain Size Distribution of the soil, the sieve analysis test was conducted as per IS: 2720 (Part 4) – 1985 (15). As per ISSCS the soil is classified as Silty sand.

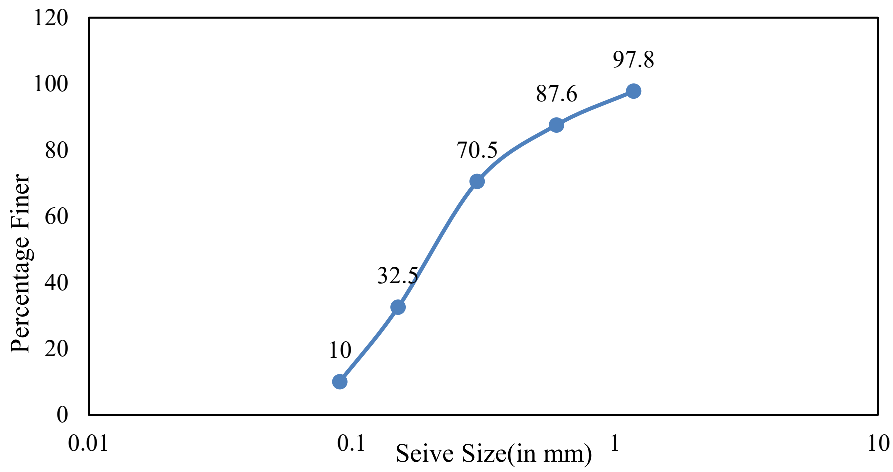

Figure 1. Grain Size Distribution of Soil

Table 4. Standard Proctor Test results for Shyorana village soil mixed with varying percentage of Egg shell powder

Sr. No.	Sample	OMC (in %)	MDD (kg/m^3)	% Variation
1	SVS	10.34	1.88	-
2	SVSE1	10	1.89	0.53
3	SVSE2	18.91	1.92	2.13
4	SVSE3	20.58	1.92	2.13
5	SVSE4	12.5	1.67	-11.17

Table 5. Standard Proctor Test results for Shyorana village soil mixed with varying percentage of Red stone dust

Sr. No.	Sample	OMC (in %)	MDD (kg/m^3)	% Variation
1	SVS	10.34	1.88	-
2	SVSR1	10.32	1.82	-3.19
3	SVSR2	10	1.93	2.66
4	SVSR3	15	1.84	-2.13
5	SVSR4	20.58	1.67	-11.17

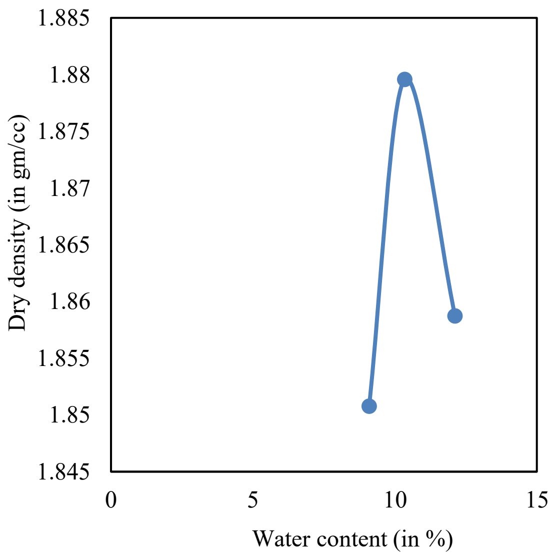

Figure 2. Standard Proctor Test results for Virgin Soil

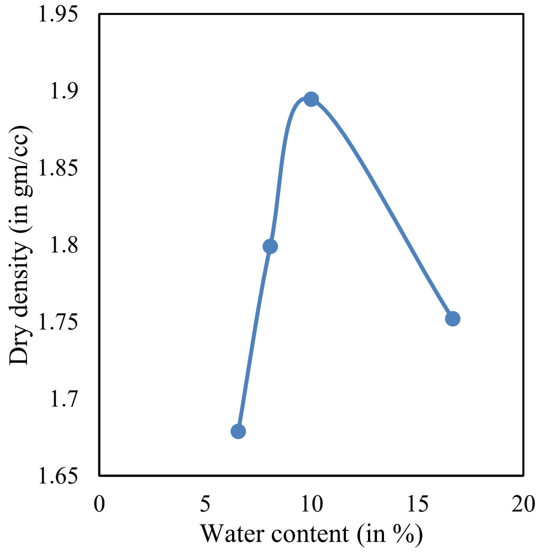

Figure 3. Shyorana Village Soil + 2.5% EggShell Powder

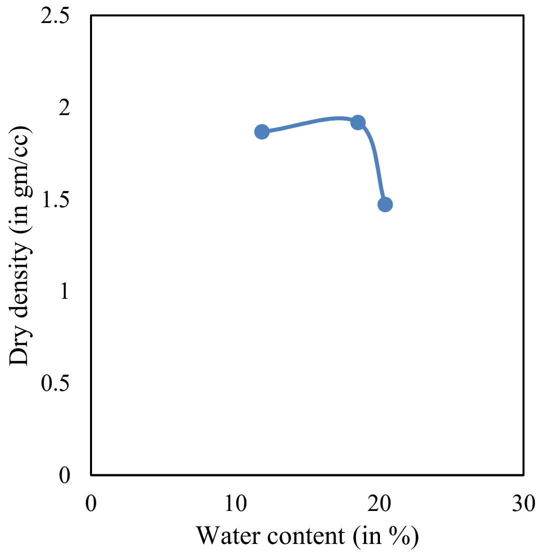

Figure 4. Shyorana Village Soil + 5% EggShell Powder

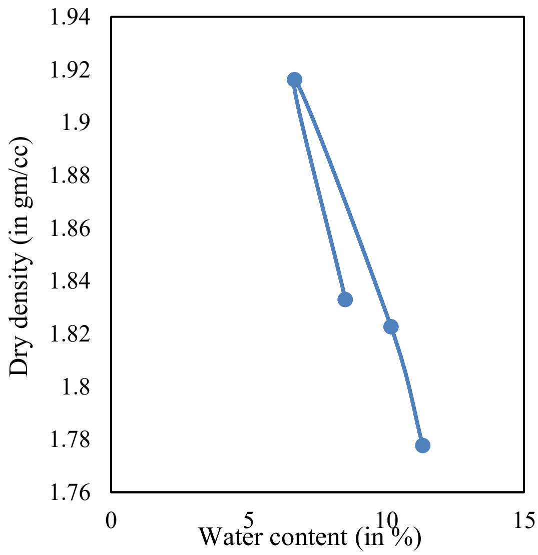

Figure 5. Shyorana Village Soil + 7.50% Egg Shell Powder

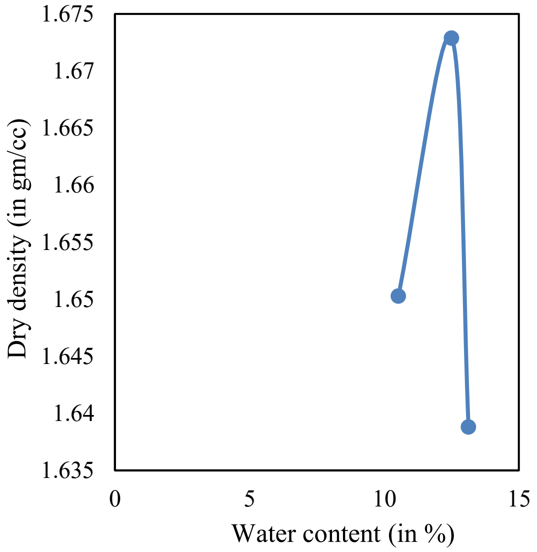

Figure 6. Shyorana Village Soil + 10.0% Egg Shell Powder

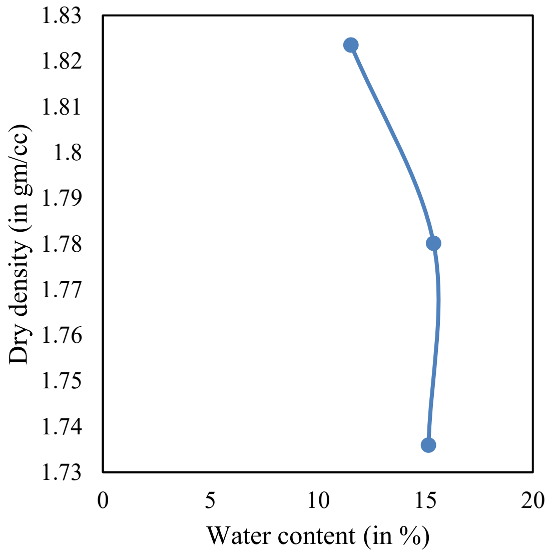

Figure 7. Shyorana Village Soil + 2% Red Stone Dust

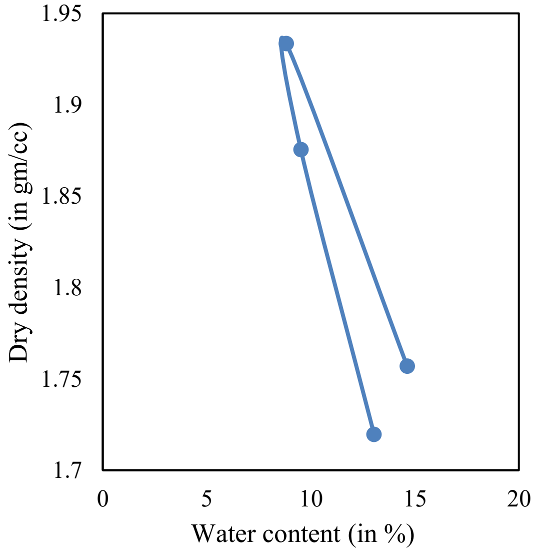

Figure 8. Shyorana Village Soil + 2% Red Stone Dust

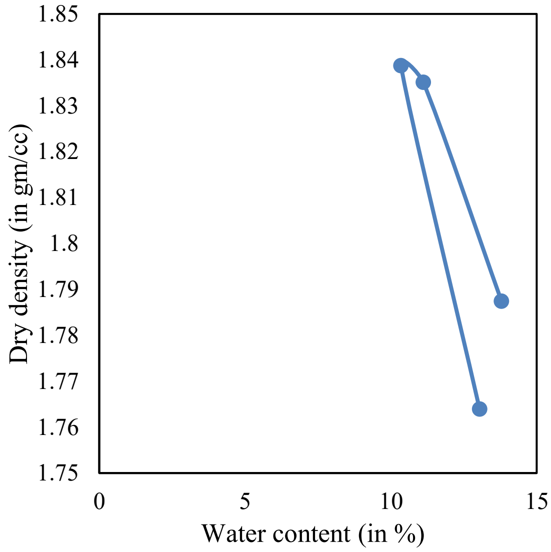

Figure 9. Shyorana Village Soil + 6.00% Red Stone Dust

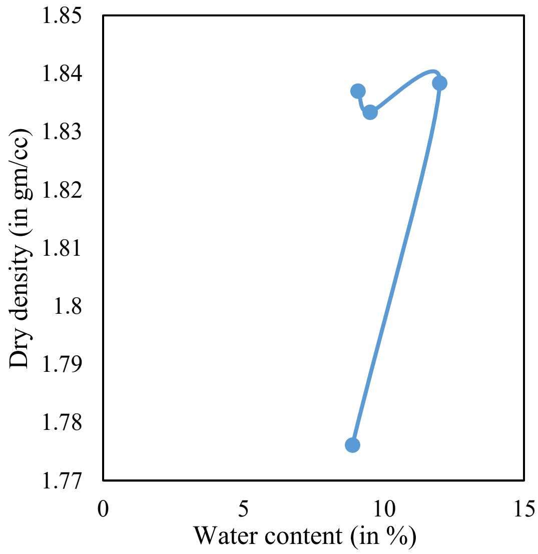

Figure 10. Shyorana Village Soil + 8% Red Stone Dust

4. CONCLUSION

In conclusion, the comparative study conducted on the characteristic compaction of Shyorana village soil using eggshell powder and red stone dust has provided valuable insights into the potential of these two additives for soil improvement. The study aimed to assess their effectiveness in enhancing the compaction properties of the soil, thereby contributing to better construction practices and soil management.

Through a comprehensive analysis of the experimental results, several key findings have emerged:

(i) Compaction Performance: Both eggshell powder and red stone dust demonstrated the ability to enhance the compaction characteristics of Shyorana village soil. The addition of these additives led to increased maximum dry density and reduced optimum moisture content, indicating improved soil compaction and density.

(ii) Comparative Effectiveness: While both additives were effective in enhancing soil compaction, their impacts differed. Eggshell powder exhibited notable benefits in terms of increasing maximum dry density and reducing optimum moisture content. Red stone dust also displayed positive effects, albeit to a slightly lesser extent. The specific impacts of each additive might be attributed to their distinct physical and chemical properties.

(iii) Sustainability Considerations: Eggshell powder offers the advantage of being a natural waste product that can be sourced locally, potentially providing an environmentally friendly and cost-effective solution for soil improvement. On the other hand, red stone dust might be readily available in certain areas but could involve environmental considerations related to extraction and transportation.

(iv) Engineering Applications: The study's findings suggest that both eggshell powder and red stone dust can be considered as potential additives for soil stabilization and compaction in construction projects. The choice between these additives would depend on factors such as their availability, cost, and the specific requirements of the project.

Further Research: While this comparative study provides valuable insights, there is room for further research to explore the long-term effects of these additives on soil stability, durability, and other engineering properties. Additionally, assessing the economic feasibility and environmental impact of large-scale implementation would contribute to a more comprehensive understanding of their practical applicability.

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