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"EXPLORING THE EFFECT OF RICE STRAW ON GEOTECHNICAL PROPERTIES FOR POORLY GRADED SAND"

KARMIT LEPCHA, Er. HEMA RANA

[1.] *M.Tech Scholar, Dept. of Civil Engineering, Indo-Global Group of Colleges*
[2.] *Assistant Professor, Dept. of Civil Engineering, Indo-Global Group of Colleges, Punjab, India*

Abstract: *India is the world's second-largest producer of rice and Punjab is among the top rice-producing states of India, with an annual output of 13 million metric tons, Punjab is also dealing with a significant problem linked to rice straw, a leftover from rice farming. This waste has become a notable concern as farmers often burn it. This research aims to investigate the effect of rice straw as a reinforcement material in poorly graded sand. Poorly graded sand has been a long-standing challenge in civil engineering and construction projects. The usual methods to stabilize soil often involve expensive and environmentally damaging processes. Therefore, there is a growing interest in exploring alternative materials that are both environmentally friendly and sustainable. The investigation begins by characterizing the poorly graded sand, revealing fundamental properties such as specific gravity, grain size distribution, optimum moisture content (OMC), and maximum dry density (MDD). The main focus of the study is to understand how rice straw influences the soil. Through IS Light Weight Compaction tests with varying percentages of rice straw (ranging from 0.25% to 1.25%), the optimal moisture content progressively increases from 10.13% to 11.46%. At the same time, maximum dry density gradually decreases from 1.86 g/cc to 1.62 g/cc. The findings suggest that rice straw may not provide a complete solution; nevertheless, this research contributes significantly to the ongoing quest for sustainable soil improvement methods in geotechnical engineering.*

Keywords: - rice straw, poorly graded sand, maximum dry density, and optimum moisture content.

1. INTRODUCTION

Rice straw is the stalk or stem of the rice plant that remains after the grains have been harvested. Punjab produces around 13 million metric tons of rice every year [10]. This fact not only highlights Punjab's proficiency in farming but also underscores the significant environmental challenge of managing rice straw. Farmers consider it as a waste product and often burn it in the fields, leading to air pollution and environmental concerns. However, with the rise of sustainability awareness and the need to explore alternative resources, researchers and innovators have turned their focus towards unlocking the hidden potential of rice straws.

The geotechnical properties of poorly graded sand have long presented challenges in civil engineering and construction projects. These soils, characterized by a lack of uniformity in particle size distribution [3], can lead to suboptimal engineering performance, including low bearing capacity and high settlement. Which often exhibit inadequate strength and compressibility for structural support. Such problematic soil can be the cause of many disasters in structural foundations, road subbases, embankments, slopes, and many other construction applications. In regions characterized by poorly graded sand, engineering solutions for enhancing soil properties and ensuring the stability of construction projects are of paramount importance. The usual methods for soil improvement often involve expensive and environmentally damaging processes, such as the addition of chemical stabilizers or extensive excavation and replacement. However, among the various innovative methods, the utilization of natural and sustainable materials has gained substantial attention, offering both environmentally friendly and cost-effective solutions. Rice straw, a byproduct of rice cultivation, has emerged as a promising candidate for soil stabilization. In numerous studies, rice straw has consistently demonstrated its effectiveness in stabilizing various soil types [1] [2] [4] [6] [9], making it a compelling choice for addressing soil engineering challenges. This thesis focuses on the experimental investigation of the impact of rice straw on the geotechnical properties of poorly graded sand. The rice straw used in this project was sourced from local farmers in Abhipur, a village situated in Punjab. Initially, the straw underwent a natural drying process to eliminate excess water. Subsequently, it was meticulously cut into smaller pieces suitable for the grinding machine. The machine played a crucial role in transforming the straw into a fine powder. To uphold the powder quality throughout the study, it was securely stored in sealed containers within a cool, dry environment, ensuring the prevention of moisture absorption and clumping. In addition, the soil sample utilized in the study was collected from a road-damaged site in Palanpur, near the T-point, also located in the state of Punjab.

This research investigates the impact of introducing rice straw powder, an agricultural by-product, to poorly graded sand, focusing on its effects on the soil's geotechnical properties. The study involves a systematic replacement of rice straw powder in poorly graded sand, the percentage replaced is 0.25%, 0.50%, 0.75%, 1.0%, and 1.25% by weight respectively. A series of comprehensive laboratory experiments was conducted to evaluate the outcomes of this innovative combination. The examination of the soil's properties encompasses specific gravity analysis using the Pycnometer method, sieve analysis for particle size distribution, and light-weight compaction test to determine compaction characteristics. Simultaneously, the study extends to the rice straw powder, subjecting it to the Light-Weight Compaction Test when blended with the soil at varying percentages.

2. LITERATURE REVIEW

Researchers have been working on making soil stable. Here are some things they have done.

Hema Rani et al. (2022): "Clayey Sand Stabilization with Organic Fiber: Rice Straw." Their research demonstrated that adding rice straw fibers to clayey sand enhances soil properties for road construction. Varying percentages of rice straw fibers (0.5% to 3%) by the dry weight of the soil and fiber sizes (0.5mm to 3mm) were tested. The results indicate a substantial increase in dry density (from 1.78 to 1.89) and CBR value (from 5.18% to 7.37%) when 2% of rice straw fibers were used.

Anusuri Uma Maheswari et al. (2022): "Stabilization of Red Clay Soil Using Rice Straw." The concept involves using chemically treated rice straw fibers to enhance soil properties. In the study, varying proportions of rice straw were mixed with soil. The research found that up to a 1.5% rice straw content positively affected liquid and plastic limits, maximum dry density, and California Bearing Ratio (CBR) values. Beyond this threshold, the advantages began to decrease.

Barun Hijam et al. (2021): "Experimental Study of Poorly Graded Sand Soil by Partial Replacement with Industrial Waste Aluminum Powder at Varying Percentage." Their research examines how adding leftover aluminum powder from the industry affects a type of sandy soil. They mixed different amounts (1%, 2%, 3%, and 4%) of aluminum powder with the soil. Tests were conducted, and the best result, a CBR value of 14.79, occurred when they replaced 2% of the soil with aluminum powder.

Nidhi Gautam et al. (2020): "Effect of Mixing Rice Straw to Enhance the Characteristics of Soil." The study aimed at reducing pollution caused by the open burning of rice straw in fields, which poses environmental and health hazards. It investigated the effectiveness of rice straw fiber powder as a soil reinforcement material.

Vishal Singh et al. (2020): "Stabilization of Clayey Soil Using Sugarcane Bagasse Ash and Rice Straw Ash." They mixed sugarcane bagasse ash into concrete, partially replacing some of the cement (from 0% to 24%) to see its effects on the properties of the cement. The results suggest that sugarcane bagasse ash can be a good replacement for cement, positively impacting strength, especially up to a 10% substitution rate. The study focused on improving shear strength and decreasing soil compressibility.

Serin Issac et al. (2018): "Stabilization of Expansive Kuttanad Clay Using Lime-Treated Rice Straw Fibers." Their study concludes that the addition of rice straw fiber, in conjunction with a modest amount of lime, has led to substantial improvements in the engineering properties of Kuttanad clay. The optimal combination of 0.5% rice straw fiber and 6% lime content has considerably increased unconfined compressive strength, rendering the treated soil more suitable for pavement construction.

Phan Thanh Chien et al. (2018): "Study on Strength Characteristics of Rice Straw Cement-Reinforced Sludge." Their research was carried out in Japan, where the practice of the fiber-cement-stabilized soil method is common. They imitated Kasaoka clay and silt with varying amounts of rice straw content and tested it with different water content percentages. Their research shows that the impact of rice straw on the compressive strength of cemented sludge depends on the mass ratio of rice straw to cement.

Kishore Kumar et al. (2016): "Stabilization of Soil by Using Agricultural Waste." Their study of the comparative analysis of two types, sugar cane straw ash, and rice husk ash, consistently indicates that sugar cane straw ash outperforms rice husk ash in enhancing soil properties. Notably, at concentrations of 4% and 6%, sugar cane straw ash demonstrates substantial improvements in geotechnical parameters. These improvements include a 12.22% increase in the liquid limit, a 7.2% increase in the plastic limit, a 44.3% increase in the plastic index, and a 5% increase in the optimum moisture content (OMC). There is a marginal decrease of 1.9% in the maximum dry density (MDD).

Samah M. El Kefafy et al. (2015): "Effect of Using Rice Straw Fiber on Slope Stability of Sand Soil." They studied various proportions of rice straw, ranging from 0.25% to 1% of random length, with a 3% water content by weight of the sand sample. They found that a ratio of 0.75% mixed with the soil sample and an edge distance of 9cm provided better slope stability. The angle of internal friction increased with the addition of 1% straw.

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3. GAP-AREA

Despite the significance of soil stabilization in geotechnical engineering, the specific impact of rice straw powder on poorly graded sand remains unexplored. This study pioneers the systematic investigation of the geotechnical properties affected by varying percentages of rice straw powder, presenting a unique contribution to the understanding and implementing environmentally sustainable and cost-effective soil stabilization practices.

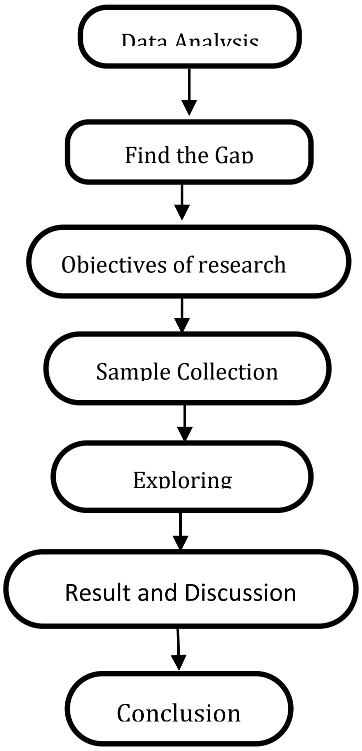
4. OBJECTIVES

To accomplish the following objectives:

1. **Explore Rice Straw's Impact:** Investigate how adding rice straw powder affects poorly graded sand, focusing on geotechnical properties.
2. **Analyze Different Percentages:** Examine the soil's behavior with different amounts of rice straw powder. Systematically study how these varying percentages impact the geotechnical properties.
3. **Initiate Comprehensive Study:** first systematic investigation into the effects of rice straw powder on poorly graded sand in geotechnical engineering.

5. METHODOLOGY

The flowchart illustrates the systematic methodology guiding the progression of this research.



5.1 Sample collection and preparation:

5.1.1. Poorly graded Sand :

The soil sample was collected from a road-damaged site in Palanpur, near the T-point in Punjab, with the specific coordinates (30.859657, 76.705408). The soil sample was then transported to the college laboratory.

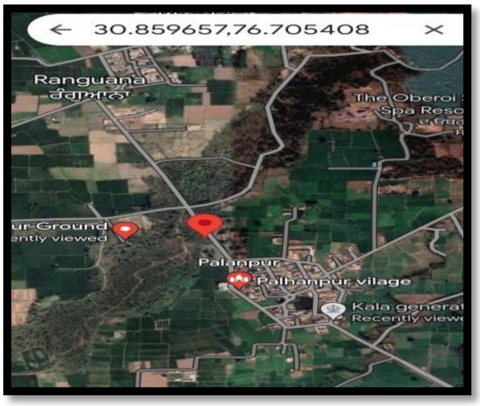


Fig-1 Location

5.1.2. Rice straw:

Rice straw was collected from the local farmers of Abhipur, a village in Punjab. Rice straw is an agricultural by-product, a waste material that is collected after the harvesting of rice. First, the rice straw was allowed to dry naturally to remove excess water. After that, it was cut into smaller pieces suitable for the grinding machine. The machine was used to transform the straw into a fine powder, which was necessary for the research. To maintain the powder quality for the study, it was stored in a cool, dry place in sealed containers. This prevented moisture from getting in and stopped clumping. These steps ensured the rice straw powder was well-suited for our research. Shown in Figure. 2.

Fig.2 Rice Straw Powder

2. Laboratory Testing:

1. Grain size distribution for Soil as per IS 2720 part-4 (1985).

2. Specific Gravity by Pycnometer method as per IS 2720 part-3 (1980).
3. Dry density of soil compaction by Core Cutter method as per IS 2720 part-29 (1975).
4. Light compaction test as per IS 2720 part-7 (1980).

6. RESULT AND DISCUSSIONS

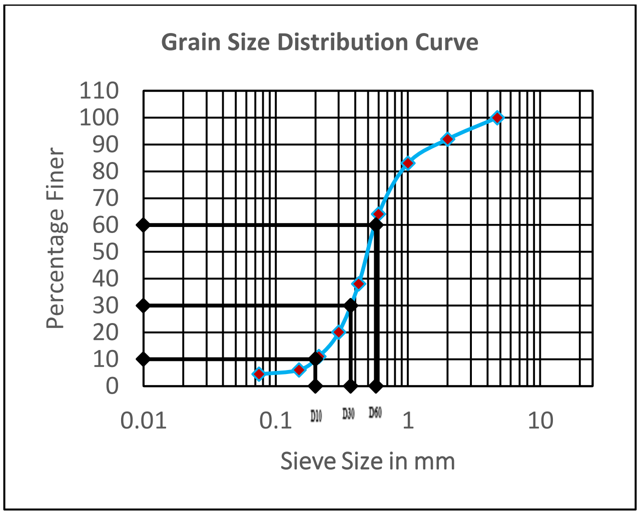
6.1 Sample Properties:

Table 1. Properties of Poorly graded sand

S.no	Property	Result	Standard results
1	Coefficient of curvature (Cc)	1.19	IS Code:2720 (part 4) -1985
2	Coefficient of uniformity (Cu)	2.88	
3	Classification	Poorly graded sand soil (SP)	
4	Water Content	6.62 %	IS Code: 2720 (part 2)- 1973
5	Specific gravity	2.63	IS Code:2720 (part 3)-1985
6	Dry density of soil compaction by Core Cutter method	2.00%	IS Code: 2720 (part 29)-1975
7	MDD	2.11%	IS Code: 2720 (part 7)-1980
8	OMC	8.1%	

6.2 Grain size distribution:

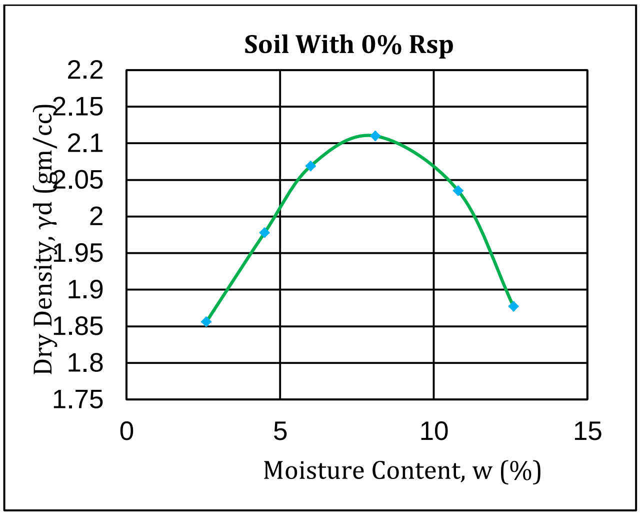
This experiment followed the procedure outlined in IS Code 2720 Part 4 (1985) and used a single disturbed soil sample. The outcomes of the test were plotted on graph no. 1. Based on the results of this experiment, the soil sample was classified as poorly graded sand (SP). The experiment revealed values for the coefficient of uniformity (Cu) value is 2.88 and the coefficient of curvature (Cc) value is 1.19 of the soil. As demonstrated in graph 1.



Graph 1 Grain size distribution curve of soil

6.3. Light Compaction Test:

This test followed the procedure outlined in IS Code 2720, Part 7 (1980). The results of this experiment indicated that the optimal moisture content (O.M.C.) is 8.1% and the maximum dry density (M.D.D.) is 2.11 g/cc, as shown below in the graph. 2.



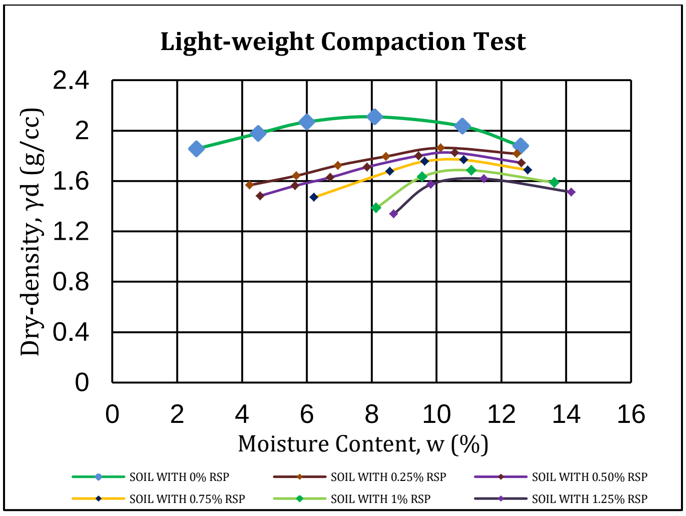
Graph 2 OMC and MDD Test of Soil

6.4. Light-weight compaction Test values of soil samples with varying percentages of rice straw powder:

This test followed the procedure outlined in IS Code 2720, Part 7 (1980). Graph 3 below illustrates the relationship between maximum dry density and optimum moisture content as revealed by the results of the lightweight compaction tests shown in Table 2.

Table 2

S.no	Percentage of Rice Straw Powder (RSP)	MDD (g/cc)	OMC (%)
1	Soil +0% RSP	2.11	8.1
2	Soil + 0.25% RSP	1.86	10.13
3	Soil + 0.50% RSP	1.82	10.56
4	Soil + 0.75% RSP	1.77	10.84
5	Soil + 1.0% RSP	1.69	11.08
6	Soil + 1.25% RSP	1.62	11.46



Graph 3 is a combined graph of light-weight compaction tests of rice straw mixed with soil at varying percentages from 0% to 1.25%.

- The table and graph above show the light-weight compaction tests of rice straw mixed with soil at varying percentages from 0% to 1.25%

7. CONCLUSION

Based on the outcomes of the current experimental investigation, the following conclusions have been ascertained:

1. According to the Indian Standard Soil Classification System (ISC System), the soil is classified as poorly graded sand (SP).
2. The specific gravity of the soil sample is 2.63.
3. In the sieve analysis of the soil, the values of Cu (coefficient of uniformity) and Cc (coefficient of curvature) were 2.88 and 1.19.
4. Dry density of soil compaction by the Core Cutter method. In this experiment, the result was 2.00%.
5. The optimum moisture content (OMC) of the soil is determined to be 8.1%, and the maximum dry density (MDD) is 2.11 g/cc.
6. After conducting the IS Light Weight Compaction test on soil samples, which involved the incorporation of varying percentages of rice straw powder (ranging from 0.25%, 0.50%, 0.75%, 1.0%, and 1.25%), it was observed that the optimum moisture content values increased progressively, measuring 10.13%, 10.56%, 10.84%, 11.08%, and 11.46%. Concurrently, this caused a gradual reduction in the maximum dry density values, which decreased to 1.86 g/cc, 1.82 g/cc, 1.77 g/cc, 1.69 g/cc, and 1.62 g/cc. The observed changes in optimum moisture content and maximum dry density indicate that the addition of rice straw powder influenced the compaction characteristics of the poorly graded sandy soil, likely due to alterations in particle arrangement and soil-water interactions.

8. FUTURE SCOPE OF THE STUDY

To improve soil stabilization, explore changes, try different agents, or add substances to the soil based on challenges observed. Use advanced testing for insights to enhance effectiveness in future applications.

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BIOGRAPHIES:

Karmit Lepcha M.Tech Scholar, Dept. of Civil Engineering, Indo Global Group of Colleges.

Er.Hema Rana Assistant Professor, Dept. of Civil Engineering, Indo-Global Group of Colleges, Punjab, India.