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ijirset@gmail.com

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Experimental Study on Usage of Guar Gum with Rice Husk Ash in Strengthening of Red Soil

¹Mr. Puneeth K, ²Mohammed Bilal Mahmood, ³Guru Prasad KM, ⁴Govardhan Nayak J, ⁵Barghav PV

¹Assistant Professor, ATME College of Engineering, Mysuru, India

^{2,3,4,5}BE Students, ATME College of Engineering, Mysuru, India

Abstract—The general aim of soil treatment in construction engineering is to improve soil properties such as stability, strength, and erosion resistance. Conventional soil treatment materials have several shortcomings, especially from an environmental standpoint. As a result, a suitable eco-friendly replacement for conventional materials is required. Guar gum is a polysaccharide commonly used as a food additive and rheology modifier. It has been used as a soil improvement material in the present study, and experimental tests were performed with the red soil using guar gum in varying percentages. In the present study, soil was also mixed by agro waste up to 10% of its quantity and checked for its strength properties. Through experiments with varying concentrations of guar gum, it was found that the soil's strength was enhanced.

KEYWORDS: Soil, Rice Husk Ash, Guar Gum

I. INTRODUCTION

Soil improvement is a process in which soil is improved in a site to enhance the prospects of on-time and safe project delivery. Soil improvement is crucial in the construction industry because, it enhances the density and stiffness of the soil; hence, preventing liquefaction which can damage the structures around earthquake-sensitive regions. It also prevents excessive settlement of reclaimed land when it is being used for roads, bridges, airports, and other construction purposes. It stabilizes contaminants in dredged soil to mitigate and consequently eliminate environmental impacts. Soil improvement can improve the shear strength of the soil; hence, preventing slips failure and increasing the bearing capacity of the soil.

Numerous soil treatment methods are already in practice; among these, cement is the most commonly used material for soil treatment. However, even with the many benefits that ordinary cement provides, it has several shortcomings, especially when viewed from an environmental perspective. The most critical of these problems are CO₂ and NO_x (nitrogen oxides) emissions and particulate air suspensions.

Biopolymers are organic polymers that are produced by different biological organisms. In nature, biopolymers can be found in large amounts. They are biodegradable and have no negative effects on the environment; therefore, they might be favorable soil-improvement material. Biopolymers can increasingly replace the conventional admixtures for the application of soil improvement and soil stabilization. Numerous studies have been conducted in the past decades to investigate the suitability and efficiency of various biopolymers for soil improvement.

The purpose of this study was to verify the engineering performance and efficiency of Guar Gum biopolymer-treated soil. Experimental tests were carried out to identify the strengthening characteristics of soils replaced by agro waste and treated with a Guar Gum biopolymer. The effect of Guar Gum treatment on the consistency limits, compaction characteristics, permeability, unconfined compressive strength, ageing and durability of the soil are studied at various percentages of Guar Gum replacement – 4% and 6%. The results of the study show promising applications of Guar Gum as a sustainable and economical option for improving soil properties.

II. MATERIALS

A. Soil

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Soil samples are collected from Bannur (Mysore district) and are tested for their geotechnical properties and strength.

B. Rice Husk Ash

Rice husk ash (RHA) is an abundantly available and renewable agriculture by-product from rice milling in the rice-producing countries. It has the highest proportion of silica content among all plant residues.



C. Guar Gum

Guar gum is a fine powder obtained by grinding guar seeds, which is used in the food, paper and construction industries. Guar gum is a gel-forming fiber from the seed of the guar plant (*Cyamopsis tetragonoloba*). Industrial applications of guar gum are possible because of its ability to form hydrogen bonding with water molecule. Thus, it is chiefly used as thickener and stabilizer. They are biodegradable and have no negative effects on the environment; therefore, they might be favorable as soil-improvement material. The trisaccharide side chain is aligned with the backbone, which provides stability and overall conformation through the use of hydrogen bonds. The most well-known characteristic of Guar Gum is its pseudo-plasticity (i.e., viscosity degradation depending on the shear rate). In nature, guar gum can be found in large amounts.

III. METHODOLOGY

- **Step 1:** Suitable soil sample will be collected for Testing.
- ❖ (The soil contents should be having the particles as 50% Sand+20% Clay+15% Gravel and +15% silt).
- **Step 2:** Basics tests are conducted on the materials to know its index and engineering properties.
- **Step 3:** The mix proportion: A suitable cohesive soil is replaced by 10% of Bagasse ash and treated with 4% and 6% of Guar Gum.
- **Step 4:** The above mix proportion is tested for index and engineering properties.

Table 3.1: Mix Proportion

Soil Proportion	Rice Husk Ash Proportion	Guar Gum Proportion
100%	-	-
100%	10%	4%
100%	10%	6%

Table 3.2: Properties of Materials

Materials	Tests Conducted	Result	
Soil	Specific Gravity	2.45	
	Unconfined Compressive strength test	C(kN/m ²)	0.33
		φ (Degree)	12
	Liquid Limit	20%	
	Plastic Limit	36.11%	
	Maximum Dry Density & OMC	1.67g/cc 16%	
Rice Husk Ash	Specific Gravity	2.21	
Guar Gum	Specific Gravity	2.00	

Table 3.3: Tests conducted on materials

Materials	Tests Conducted
• Soil	<ul style="list-style-type: none"> ➤ Specific gravity ➤ Consistency ➤ Dry density & OMC ➤ Unconfined Compressive Strength Test
• Rice Husk	➤ Specific gravity
• Guar Gum	



<ul style="list-style-type: none"> • Soil mixed with Rice Husk ash & Biopolymer 	➤ Specific gravity
	➤ Consistency
	➤ Dry density & OMC
	➤ Unconfined
	Compressive Strength Test

IV. RESULTS & DISCUSSION

The Soil was mixed with 10% of Rice Husk Ash and 4% to 6% of Guar Gum and tested for its Consistency limits, Maximum Dry Density, OMC and Shear Strength parameters. The following Results were obtained.

Table 4.1: Tests results on soil & Mix Proportion

Tests conducted	Soil + 10% Bagasse Ash + 4% Guar Gum	Soil + 10% Bagasse Ash + 6% Guar Gum
☐ Consistency limits		
• Liquid Limit (%)	23	27
• Plastic Limit (%)	39.56	40.3
• Flow Index (%)	51.2	52.1
☐ MDD g/cc	1.83	2.36
☐ OMC (%)	20	22
• C (kN/m ²)	0.56	0.62
• φ (Degree)	9	18

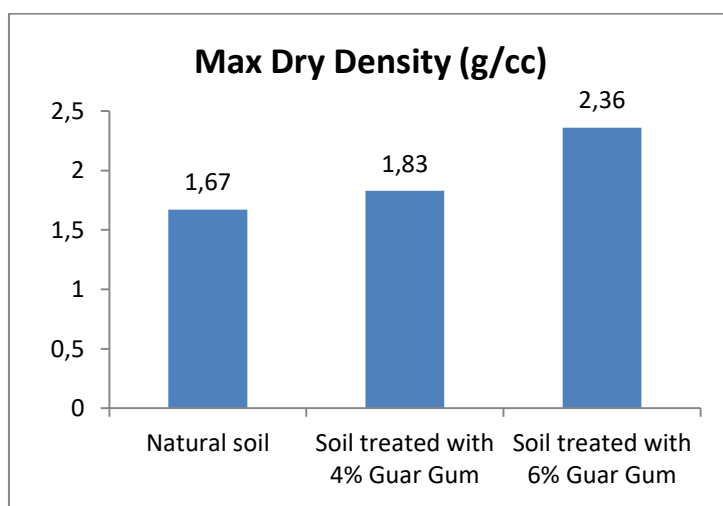


Fig 4.1: Variation of MDD in soil & treated mixture

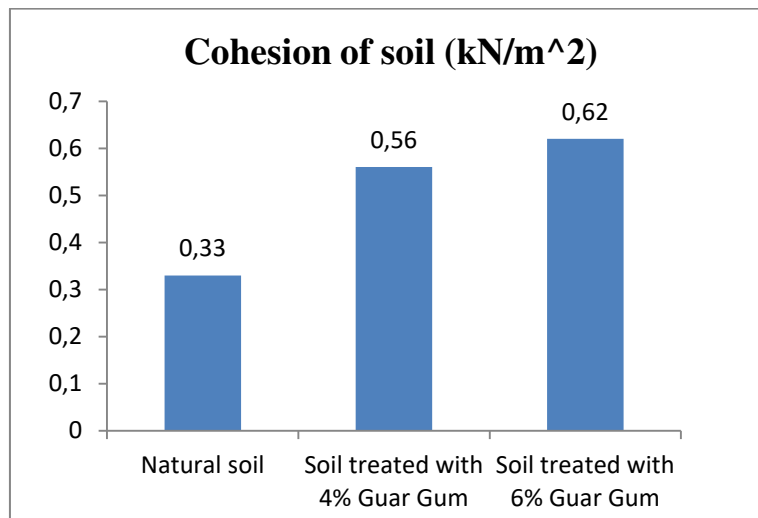


Fig 4.2: Variation of Cohesion in soil & treated mixture

V. CONCLUSION

1. Rice Husk ash can be used as a replacement for soil upto 10%.
2. Usage of Guar Gum (Biopolymer) as an additive improves the engineering properties of the cohesive soil.
3. Increase in Guar Gum percentage enhances the liquid limit & plastic limit which indicates the soil becoming viscous.
4. Soil replaced with 10% of Rice Husk ash and treated with 4% guar gum enhances the cohesion by 70%
5. Soil replaced with 10% of Rice Husk ash and treated with 6% guar gum enhances the cohesion by 88%.
6. The percentage of Guar Gum usage can be limited to 6% in treating the soil to enhance its strength. Higher the Guar Gum makes the soil viscous.

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