

REVIEW ON IMPROVISING RED SOIL'S GEOTECHNICAL PERFORMANCE WITH POLYPROPYLENE AND GYPSUM

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Abstract - In civil engineering, the foundation is critical for any land base construction and must be able to withstand the incoming loads without failing. In some areas, the soil may be poor and unable to withstand the incoming stresses. Soil stabilization is required in such circumstances. Red soil covers 10.6% of the Indian geographical area. The color of red soil is due to a high percentage of iron in the soil. Red soil is used in this research. In this research an attempt to study various geotechnical properties and improved the red soil properties by adding different percentages of polypropylene and gypsum.

In this study red soil is collected and transported from the district of Rath in Uttar Pradesh. For this study we take polypropylene as 1%, 1.5%, 2% and constant 5% of added Gypsum to the soil.

Key Words: Soil stabilization, Red soil, polypropylene, Gypsum, CBR etc.

1. INTRODUCTION

Soil stabilization is a process that alters and improves the engineering properties of the soil in order to make it more suitable for building. Soil stabilization is a civil engineering technique for refining and improving soil engineering properties including mechanical strength, permeability, compressibility, hardness, and plasticity. The base soil serves as the foundation for any construction project, for a house, a road, or an airport. Furthermore, soil is an essential building material to stand any structure. As a result, soil should have properties that enable it to form a solid base.

Soil stabilization is a common practice in the construction of airfields, parking lots, landfills, embankments, highways and foundations, waterway maintenance, agriculture, and mining sites.

Soil stabilization is a critical component of various civil engineering projects. Without removing the entire soil, the most effective technique is to use appropriate accessible. methods and materials to enhance the soil qualities. As a result, soil stabilization is thought to be the best strategy for improving soil geotechnical parameters. Chemical additives, thermal energy, compaction, and plant-based or syntheticFiber reinforcing are all common stabilization approaches. Straw, coir, palm, sisal, and jute are examples of plant-based fiber reinforcement materials that are inexpensive. Synthetic fiber reinforcing materials, such as polypropylene, nylon, rubber, or plastic, can also help reduce waste. Research into the use of waste materials to stabilize soil is currently a global trend, as surplus waste materials pose public safety and logistical issues in terms of disposal

2. MATERIAL USED

In this study, the following materials were used:

- i) Red Soil
- ii) Polypropylene
- iii) Gypsum

2.1 RED SOIL

The soil sample for this study was taken in the district of Rath in Uttar Pradesh. The earth is a bright crimson color. Red soil is a type of soil that forms in warm temperatures and is common in damp climates with deciduous or mixed woods. The red soil's texture ranges from sandy to clay, with loam accounting for the majority of it.

Table -1: Geotechnical properties of red soil

Specific Gravity	2.64
Liquid Limit	31.03%
Plastic limit	20.77%
Plasticity Index	10.16%
Max Dry Density	1.9 gm/cc
Optimum Moisture content	14.2%
CBR (2.5mm penetration)	6.64
Cohesion (C)	0.72kg/cm ²
Angle of internal friction (Φ)	14

2.2 POLYPROPYLENE

Polypropylene's starting material is nonnumeric C₃H₆, a completely hydrocarbon compound. Polypropylene fibers have particularly beneficial qualities due to their form of polymerization, high molecular weight, and the way they are processed into fibers. Polypropylene fiber is a single fiber with a diameter of 0.034mm and comes in lengths of 6mm, 12mm, and 20mm.

Table - 2: Characteristics of Polypropylene

Length	6mm
Diameter	0.034mm
Specific Gravity	0.91
Moisture absorption	0% to 0.05%
Relative Density	0.91
Tensile Strength	550-700 MPa
Percentage Elongation at failure	21%
Modulus of Elasticity (E)	3.5-6.8 GN/m ²
Thermal Conductivity	6(with air as 1)
Melting Point	165°C
Softening Point	140°C
Alkali Resistance	Low

2.3 Gypsum

Gypsum powder is chemically known as calcium sulfate dihydrate (CaSO₄·2H₂O), meaning it contains calcium, sulfur, oxygen, and water molecules. Gypsum is a widely used building material that comprises 70% CaSO₄ and can be utilized in the construction of buildings. In terms of chemistry, gypsum is a calcium sulphate that contains two molecules of water, or CaSO₄, 2H₂O. It is a crystalline material that dissolves in weak hydrochloric acid and water with very little difficulty, but not in sulfuric acid. It is made up of 20.9% water and 79.1% calcium sulphate.

3. Literature Review

T.N Dave et.al (2020)

The use of polypropylene fibers (PPF) for the stabilization of expansive soil obtained from Dedicated Freight Corridor (DFC) project site Bhestan near Surat. In this research, PPF has been mixed with soil in proportions of 0.75%, 1.5%, 2.0%, 2.25%, and 2.5%.

Tharini et.al (2020)

The laboratory conducted for study the performance on Black cotton soil reinforced with polypropylene fiber mixed at 0.2%, 0.3%, 0.4%, and 0.5%. The soil was gathered near PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, India Petry & Little (2002).

Thomas M. Petry and Dallas N. Little (2022)

Reviewed 60 years of research on expansive clay soils. These soils swell and shrink with moisture changes, causing structural damage. The paper summarizes key advances, current stabilization practices, and future research directions.

Amiri, Kalantari & Porhonor (2023):

Mohammad Amiri, Behzad Kalantari, and Fatemeh Porhonor (2023) studied how heating red soil (100–900 °C) changes its structure and strength. New minerals like mullite and anorthite formed, increasing strength up to 20 times, showing thermal treatment improves soil properties for construction.

Singh & Kumar (2023)

Gypsum-Stabilized Low Plasticity Soils In their 2023 study, Singh & Kumar investigated the influence of gypsum stabilization on low plasticity soils, including red soils with similar properties. They found that the addition of gypsum led to a reduction in Atterberg limits, indicating reduced plasticity and improved workability. The chemical interaction between calcium from gypsum and the soil particles resulted in enhanced aggregation and slightly increased strength values in Compaction and California Bearing Ratio (CBR) tests. While the effect was more pronounced in soils with higher clay content, the study demonstrated that gypsum is a promising stabilizer for soils exhibiting poor engineering behavior, particularly in regions where traditional stabilizers like lime or cement are expensive or unavailable.

Ahmed & Islam (2024)

Combined Effects of Fibers and Chemical Stabilizers Ahmed and Islam (2024) conducted a comparative study on the combined effects of polymeric fibers and chemical stabilizers (including gypsum and lime) on expansive soils. They reported that when polymer fibers were used together with gypsum, there was a significant improvement in strength, stiffness, and resilience to moisture changes compared to using either additive alone. The fibers provided mechanical reinforcement, while gypsum improved particle bonding and reduced swelling potential. The combined stabilization technique showed improved performance in swelling potential tests, suggesting that composite stabilization can effectively address both strength and volumetric instability problems in problematic soils similar to red soils.

Purohit et al. (2025)

Red Soil Stabilization Using Waste Plastic Additives Purohit et al. (2025) investigated the use of waste plastic materials (including polypropylene waste strips) in the stabilization of red soils, with an emphasis on environmental sustainability. Their work demonstrated that inclusion of waste plastic improved tensile strength and ductility and reduced the formation of cracks during drying and wetting cycles. In addition to benefits in mechanical behavior, the use of waste plastic helped reduce the environmental burden of plastic disposal. Coupled with gypsum treatment, the composite approach was found to enhance soil performance significantly more than either additive used alone. This study provides important evidence for environmentally conscious stabilization techniques suitable for regions with abundant red soil.

4. METHODOLOGY

The red soil used in this study was collected from a local site, air-dried, pulverized, and sieved to remove impurities. Polypropylene fibers and powdered gypsum were used as reinforcement and stabilizing agents, respectively, and added to the soil in varying proportions by dry weight. The soil-gypsum mixture was first blended uniformly, followed by the gradual addition of polypropylene fibers to ensure proper dispersion. Water corresponding to the optimum moisture content was then added, and specimens were prepared at maximum dry density. Laboratory tests including Atterberg

limits, Standard Proctor compaction, unconfined compressive strength (UCS), and California Bearing Ratio (CBR) were conducted on both untreated and treated soil samples as per relevant Indian Standard codes. UCS specimens were cured for 7, 14, and 28 days to study strength development. The results were analyzed and compared with those of natural red soil to evaluate the improvement in geotechnical performance due to the combined use of polypropylene fibers and gypsum.

5. CONCLUSION

The use of polypropylene fibers and gypsum significantly improves the engineering properties of red soil. Polypropylene fibers enhance tensile strength, ductility, and resistance to cracking, while gypsum reduces plasticity and increases strength through improved particle bonding. The combined stabilization of red soil with polypropylene and gypsum results in better compaction characteristics, increased CBR and UCS values, and overall improved load-bearing capacity. This method offers a cost-effective and sustainable solution for using red soil in pavement subgrades and foundation applications, provided that optimum proportions of additives are used.

6. REFERENCE

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