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ENHANCING PAVEMENT SUBGRADE PERFORMANCE THROUGH SUSTAINABLE INTEGRATION OF BIOPOLYMERS IN BLACK COTTON SOIL

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ABSTRACT :

Black cotton Soils pose to problem for civil engineers in general and geotechnical engineers in particular. They cause damage to foundation of structures and pavements. Especially for pavements, the pavement subgrade is made by black cotton soil the pavement performance is poor against load carrying and settlement. Soil stabilization is the act of modifying and enhancing certain aspects of soil, either chemically, mechanically and biologically. In this study biological strengthening adopted to change the black cotton soil properties to enhance the strength of subgrade. This research explores the effective of various biopolymers (Xanthan &Agar Agar gums) formulations mixed in black cotton soil with 1%,3% and 5% by weight of soil to improving the strength, moisture resistance of subgrade soil. Laboratory tests performed to assess the mechanical properties of biopolymer treated subgrade at different curing periods. These findings have shown that maximum strength achieved at 28 days curing period at 3% biopolymer by weight of soil.

Keywords: Black cotton soil, Stabilization, Biopolymers.

INTRODUCTION

GENERAL

Soil is essential to many different types of infrastructure in a number of ways. The foundation for constructing roads, bridges, buildings, and other infrastructure is provided by the soil. The design and construction of foundations are determined by the soil's stability and load-bearing capacity. For the construction of retaining walls and embankments for infrastructure projects like roads, trains, and water management systems, soil is utilized. The subgrade for pavements and roads is soil. Since the subgrade of pavement serves as the basis for road infrastructure,A strong subgrade prolongs the life of the pavements, minimizes settling, and assures load bearing capacity. It acts as the foundational layer influencing the overall pavement system's performance and structural integrity. Various soil types, include sand, gravel, clay that is utilized as the basis for many kinds of infrastructure. The expansive soil or black cotton that makes up the pavement subgrade has several detrimental effects on its strength, including high levels of swelling and shrinkage, low bearing capacity, low shear strength, high activity, high compressible strength, and high plasticity.

The substantial concentration of the mineral "montmorillonite" in black cotton soil is the cause of the soil's detrimental effects on subgrade strength. One kind of clay mineral that is a part of the smectite group is called montmorillonite. Gibbsite is the structural unit of montmorillonite, and it is arranged in a single layer between sheets of silica. The mineral montmorillonite is created by combining many structural units together via van der Waals forces in comparison to hydrogen bonds, a weak force. Since water molecules are dipolar and negatively charged on the silica sheet's surface, they cause two structural units to divide further, which causes the mineral units to expand. The cation exchange capacity of montmorillonite is facilitated by its ability to attract and retain positively charged ions, or cations, due to its negative charge. Expanding clay soil, another name for black cotton soil, is a special kind of soil that can be difficult to work with while building infrastructure. Therefore, one of the main ways to improve the mechanical and physical qualities of this soil and guarantee the stability and lifetime of structures erected on it is to strengthen it. There are a number of ways to strengthen soil, including:

1. Physical methods include compaction, grouting, and preloading.
2. Using chemicals like fly ash, cement, and lime to strengthen.
3. Biological technologies, such Geopolymers and Biopolymers, for strengthening.

Fortifying When black cotton soil is prepared physically, procedures like compaction, stabilization, and reinforcement are usually used. Improved load bearing capacity, decreased settling, increased longevity, and cost effectiveness are some benefits of this approach. However, physical techniques of strengthening black cotton soil can be time-consuming and, if not done correctly, might have detrimental effects on the environment. Moreover, ongoing maintenance may be required to guarantee the methods' continued efficacy.Enhancing Utilizing additives like lime, cement, and fly ash, black cotton soil by chemical means usually entails soil stability. Swelling and shrinking can be considerably reduced by chemical additions. The permeability of the soil can be decreased by chemical additives, which will lessen the requirement for routine maintenance. On the other hand, chemical stabilization can be more widespread and has environmental ramifications when substantial amounts of chemicals are needed.When using biological techniques to strengthen Black cotton soil, soil stabilization with the help of geopolymers and biopolymers is usually required. Biological techniques have been developed to address the issues and limitations associated with soil chemical and physical stabilization methods. Biopolymers are polymers that are synthesized from biological materials or wholly biosynthesized by living creatures, derived from natural sources such as live organisms' cells. Biopolymers are widely employed in food and medicine applications and are environmentally beneficial. Biopolymers have recently shown promise in soil strengthening, dust control, erosion reduction, and even water treatment.

METHODOLOGY

BLACK COTTON SOIL:

Known by several names, including regur soil, black cotton soil, and black clay soil, black cotton soil is a unique kind of soil with a wide distribution around the globe. Its evocative dark hue and propensity to aid in the development of cotton crops are the sources of its moniker. Because it affects agriculture and engineering, this kind of soil is very important. From fields close to Rajam, we obtained this soil. This soil has the following unique characteristics.

Origin and Formation: The earth used to produce black cotton usually originates in areas with a semi-arid to sub-humid environment, which is marked by seasons that alternate between being wet and dry. Predominantly, iron and magnesium-rich basaltic rocks that have weathered are responsible for its formation. The fine-grained particles of these rocks are broken down by weathering over time, creating the soil that is rich in clay.

Physical Characteristics: The high clay content, usually between 50% and 70%, is what makes black cotton soil unique. The soil's cohesiveness and plasticity are a result of its high clay content. It's finely grained while dry, but difficult to work with when wet since it gets sticky and very plastic.

Chemical Composition: Black cotton soil has a dark color due to the presence of substantial amounts of organic matter in addition to clay minerals. Organic matter improves the soil's ability to hold nutrients and increase its fertility, which qualifies it for use in specific agricultural practices. Black cotton soil has special hydraulic qualities, such as a large capacity for holding onto water. Its inability to efficiently drain extra water causes it to get waterlogged during the rainy season. In contrast, the soil contracts and develops surface fissures at the surface during dry spells.

Considerations for Engineering: The expansive character of black cotton soil presents difficulties for building projects. Wet causes it to greatly expand, applying pressure to the structures; dry conditions cause it to contract, causing fractures to appear. Often, in order to improve the engineering properties of soil, engineers will use stabilization procedures like mechanical reinforcement or lime stabilization.

In areas where black cotton soil is common, farmers, engineers, and legislators must have a thorough understanding of its characteristics and behaviour. Its fertility may be harnessed for agricultural productivity and its obstacles for infrastructure development can be mitigated with the use of efficient soil management techniques and engineering solutions.

CONCLUSIONS :

Biopolymers can be used as a supplement to enhance the strength and properties of black cotton soil. Biopolymers can be suggested to strengthening and stabilize the subgrade pavements. Biopolymers have biobased enzymes , these enzymes catalyse the chemical reaction (soil-to-ion interaction) Between clay particles and cationic organic matter with in the soil, resulting in an overall increase of soil strength.

- Biopolymers enhances the strength of black cotton soil. For instance CBR of untreated black cotton soil is 1.77% and CBR of treated black cotton soil at 28 days curing period is 3.27%. It is observed that 84.75% of strength has been increased.
- Biopolymers enhances the unconfined compressive strength of black cotton soil. For instance UCS of untreated black cotton soil is (1.42kg/cm^2) and UCS of treated black cotton soil at 28 days curing period is (17.81 kg/cm^2).
- Biopolymers enhance the inter particle cohesion (c) resulting in sufficient reduction in surface erosion and land degradation.
- Biopolymers are environmentally friendly and as they are mostly hydrocarbons with low CO_2 foot prints compared with the conventional soil binders.
- Active application of biopolymers in field could also reduce the cost of biopolymers via mass production and expansion of the global biopolymer market.
- Biopolymers usage in subgrade black cotton soil for strengthening can reduce the causes for significant failures in pavement such as vertical compressive strain at the top of subgrade and horizontal tensile strain at the bottom of the bitumen layer.

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