

SOIL STABILIZATION USING BIOPOLYMER (WITH XANTHANGUM)

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ABSTRACT - Chemical stabilization is one of the most widely used techniques for improving weak soils and permitting its use in geo-technical projects. Although alternative binders can also be used, Portland cement is still the most commonly used binder to stabilize soils. But since the use of Portland cement is associated with a host of environmental problems, microbiological-based methods have been looked into as viable substitutes for conventional soil stabilizing methods. Here, one of the practical, sustainable, and ecologically friendly material options for soil stabilization is the use of bio-polymers made from living organisms. Bio-polymers, however, can have a wider range of physical properties based on their types and compositions. The primary objective of this work is to examine the effects of small concentrations of bio-polymers, xanthan gum in particular, on the physical properties of red soil at (0%, 10%, and 20%). This study's characteristics include specific gravity, sieve analysis, shrinkage limit, plastic limit, and liquid limit. The shear strengths of both treated and untreated soil were experimentally evaluated at various curing times using an unconfined compressive strength test.

KEYWORDS- Soil Stabilization , Foundation , CBR Test , Proctor Test , UCS Test, Engineering Properties, Soil Strength

1. INTRODUCTION

Soil improvement techniques have been a focus of geo technical engineering for a long time, with historical examples including surface compaction, drainage methods, vibration methods, and more [1]. Ancient civilizations used natural materials like mud and bitumen for various construction needs, while in ancient Rome, Roman concrete was made from volcanic ash, aggregates, and a binder [2]. After the Industrial Revolution, ordinary Portland cement became popular for soil stabilization, but its

Excessive use has had negative environmental consequences, particularly in terms of carbon dioxide emissions [3]. As a response, geotechnical engineers have started exploring bio-mediated soil improvement technologies as a more environmentally friendly alternative [4]. These techniques involve using biopolymers and methods like microbial-induced calcite precipitation. Biopolymers, which are biodegradable polymers, have shown promise in improving soil. This paper reviews recent studies on the application.

Bio-polymer, rising technical engineering, including experimental results, theoretical explanations, and case studies [5]. It also summarizes the strengthening mechanisms between common bio-polymers and soils based on microscopic interactions. Soil stabilization is a crucial aspect of civil engineering and construction, aiming to enhance the engineering properties of soil to meet the requirements of various construction projects. [6]

Traditional methods often involve chemical additives or mechanical processes, which may pose environmental concerns and sustainability challenges. In recent years, there has been a growing interest in exploring sustainable and eco-friendly alternatives for soil stabilization, with biopolymers emerging as promising candidates. Biopolymers are naturally occurring polymers derived from renewable resources such as plants, animals, and microorganisms, offering advantages over conventional stabilizers such as biodegradability, non-toxicity, and compatibility with the environment.

Biopolymer-based soil stabilization involves the use of natural polymers to improve the engineering properties of soil [9]. These polymers can be classified into various categories based on their origin and chemical composition, including polysaccharides, proteins, and microbial polymers. The mechanism of soil stabilization with biopolymers often involves physical and chemical interactions between the polymer molecules and soil particles. They can act as binders, creating a network that strengthens the soil structure and enhances its load-bearing capacity [10]. Biopolymer-based soil stabilization has diverse applications across various sectors, including road construction, slope stabilization, erosion control, and land reclamation. In road construction, biopolymers can improve the strength

and durability of road bases and subgrades, reducing maintenance costs and extending the service life of roads. In slope stabilization and erosion control, biopolymers can stabilize soil slopes, prevent soil erosion, and revegetate degraded land, promoting sustainable solutions that minimize environmental impact and promote ecosystem health. Despite the numerous benefits of biopolymer-based soil stabilization, several challenges remain to be addressed, such as cost-effectiveness and scalability of biopolymer production and application [7]. Advances in biotechnology and materials science are expected to drive innovation in this field, leading to novel biopolymer formulations with enhanced performance and versatility [8].

1.1 Soil Stabilization

Traditional soil stabilization methods have several drawbacks and limitations compared to biopolymers. Firstly, these methods often involve the use of chemical additives that can have negative environmental consequences. These additives may contaminate the soil and groundwater, leading to ecosystem degradation [11]. Moreover, many traditional stabilizers rely on non-renewable resources, contributing to sustainability challenges. Additionally, the production and transportation of traditional stabilizers result in significant energy consumption and greenhouse gas emissions, exacerbating climate change. Unlike biopolymers, traditional stabilizers are not biodegradable and can persist in the environment for extended periods, potentially harming wildlife. [12]

Furthermore, some chemical additives used in traditional methods can pose health risks to workers and nearby communities. Cost inefficiency is another drawback, with high material, labor, and equipment expenses, as well

as ongoing maintenance and repair costs. Traditional stabilizers also have limited versatility, as they may not be suitable for all soil types or environmental conditions [13]. Therefore, exploring alternative approaches like biopolymer-based stabilization is crucial for promoting sustainable soil management practices and minimizing environmental [14].

2. METHODOLOGY

2.1 Material Used

Xanthan gum, also known as XG, is a polysaccharide derived from the fermentation of glucose. [15] The proportion to use the biopolymer in soil (0%, 10% and 20%). XG has the unique property of being soluble in both hot and cold water, and it enhances the viscosity of the substances it is mixed with. [16] It is widely used in various industries such as cosmetics, food, agriculture, oil drilling, and civil engineering. Solutions containing XG exhibit non-Newtonian behavior, with their viscosity decreasing as shear stress increases.

2.2 Specimen Preparation

In the process of specimen preparation, an electronic balance was used to measure and batch all mixing quantities. [17] The mixing process involved two approaches.



Fig.1(preparation of soil sample)

In the first approach, the dry components (base soil and biopolymers) were mixed together slowly for a few minutes. [18]

Four types of biopolymers (XG, GG, CHI, and BG) were mixed into the soil at concentrations of 0%, 10%, and 20% relative to the mass of the base soil. After mixing a biopolymer with the soil, water was sprayed into the mixture until it reached 16.5% of the mass of the base soil. [19] The water content of 16.5% was chosen as the optimum level for specimen preparation, as lower water contents resulted in non-uniform soil samples and higher water contents made the specimen too soft. [20] Throughout the process of adding water, the soil-biopolymer mixture was continuously mixed to ensure even distribution.

3. EXPERIMENTS:

3.1 UCSTest

unconfined compression test, also known as a cylinder compression test, is the appropriate method for determining the compressive strength of a cohesive soil, regardless of the presence of biopolymers. [21] The test involves applying an axial load with a strain rate of 1.5%/min, following the American Society for Testing and Materials Standard (ASTM) ASTM D2166/D2166M36. [22]

The compressive strength is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen. Additionally, Young's modulus, E_c , can be obtained from this test by recording the applied load and longitudinal deformation and extracting it from the slope of a straight line passing through the origin.

3.2 CBRTTest

To use a CBR testing machine, obtain a representative undisturbed or remolded soil sample. [23] Conduct a moisture content

test and adjust the moisture content to the desired value. [24] Assemble the mould assembly by attaching the base plate to the mould and securing the extension collar on top of the mould. [25] If the soil sample is cohesive, line the mould with a thin layer of filter paper or a suitable release agent.

[26] Compact each layer in layers and avoid over compaction. Measure and record the height (H₀) and diameter (D₀) of the compacted soil sample using vernier calipers or a ruler.

4.2 PROCTOR

3.3 PROCTOR Test

To test soil for compaction, obtain a representative soil sample, remove any organic materials or large particles, and place it in a Proctor mould.

[27] Fill the mould

in three equal layers, compact each layer, trim excess soil, and determine the weight of the compacted soil. Repeat

the compaction process for additional moisture content levels, usually 2-

3 more times. [28] Dry the samples in an oven or dry in apparatus at 230-250°F for at least 24 hours until the samples reach a constant weight.

[29] Calculate the moisture content for each sample using the

formula: Moisture Content (%) = $\frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Dry Weight}} \times 100$.

Plot moisture content versus dry density curve using the obtained values. Determine optimal moisture content and maximum dry density from the curve and repeat the process to obtain an

range of compacted samples with different moisture contents. [30] Remove soil samples carefully and place them in a moisture content container.

4 RESULTS:

4.1 UCS

Shows the Xanthan is used the shear strength increase in the maximum dry density and moisture content under the different proportion of bio used shows graph (Fig-2)

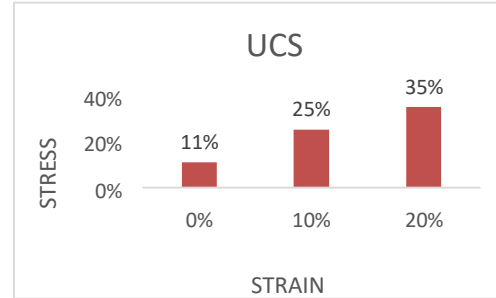
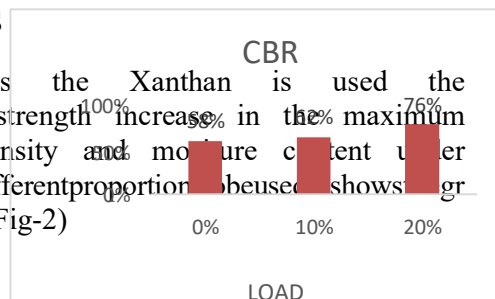


FIG-2

You may find the maximum dry unit weight and ideal water weight on one axis content of this weight by and the water using a graph that plots content on another the dry unit [31] using

(0%, 10%, 20%)

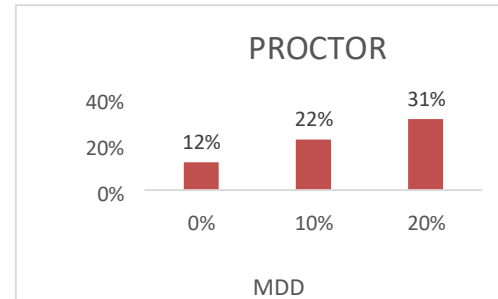


FIG-3

4.3 CBR

DIAL GAGE

Fig-4

5. WITHOUT BIO-POLYMER:

Compared to with bio polymer shows the more Xanthan gum improves soil strength and stiffness. [32, 33] Xanthan gum decreases soil hydraulic conductivity. Reduces soil loss and infiltration. In comparison to unstabilized

oil,thechemical reaction.

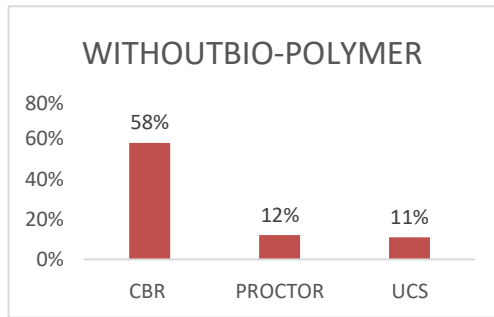


FIG-5

5.1 WITH BIO-POLYMER:

An ideal solution for expansive subgrade stabilization, xanthan gum at 20% concentration greatly increased the unconfined compressive strength, elastic modulus, and CBR values of the soil. [34, 35]

Because of its higher adhesive strength and ability to crosslink with soil particles, xanthan gum dramatically increased soil strength up to a 10% dosage. This also improved unconfined compressive strength (UCS) and consolidation characteristics. The CBR value of fines and soil contaminated with UCO is increased by xanthan gum. In comparison to natural sand soil, optimal of 0.4% boosts CBR by 30%, helping to stabilize the soil for pavement projects.

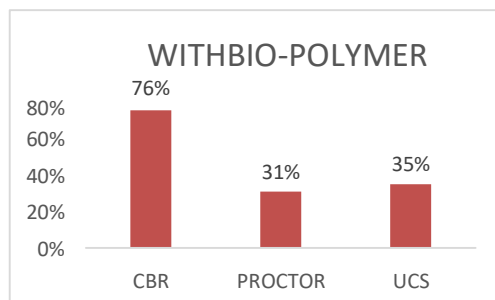


Fig-6

6. CONCLUSIONS:

Because of its capacity to enhance soil structure, augment water retention, and lessen erosion, this xanthan gum has demonstrated potential in soil stabilization applications. Its

attractiveness as a sustainable solution for soil stabilization projects is further enhanced by its biodegradability and non-toxic characteristics. This study investigates the potential of xanthan gum, an environmentally beneficial biopolymer derived from microbial sources, to stabilize leftover soil. The stability of xanthan gum is a significant factor in improving the mechanical properties of fine-grained collapsible soil, leading to a sustainable and environmentally friendly alternative to conventional soil additives. [36] According to the results of the UCS test, stabilizing the peat with xanthan gum increased its shear strength under natural settings; after 28 days, the stabilized peat's strength was six times greater than the original. The results for the maximum dry density and the optimal moisture content showed a notable but little decline, respectively.

7. RECOMMENDATION:

One useful soil stabilization technique to increase soil cohesion and stability is xanthan gum. [37, 38] Usually combined with water, it is applied to the soil or mixed directly into the soil to improve its qualities, especially in building and erosion management projects. To increase soil cohesion and stability, especially in construction and erosion control operations, xanthan gum is sprayed as a soil stabilizer. Consult a specialist in soil stabilization since the dosage varies based on the type of soil and the project requirements. A soil stabilizer called xanthan gum is applied to improve soil cohesiveness and stability, particularly in construction and erosion control projects. [39, 40] See a soil stabilization specialist as the dosage varies depending on the kind of soil and the needs of the project.

8. REFERENCES:

1. M.H.ZNie,MubashirAziz(2022)Strengtheningpotentialofxanthangumbiopolymer in stabilizing weaksub grade soil,(UCS test, CBR testandPermeability test)
2. KumarGupta(2023)Soilstabilizationbyusingbio-polymerofxanthangum,(CBRtestandUCS test)
3. N. shariatmadari ,MohammedRezaand Amiri tasuji(2023)Experimentalstudyontheeffectsofchitosan bio-polymers on sandysoilstabilization,(Compactiontest,CBRtestand permeability test)
4. Q.O.Babatunde , Yong-Hoon Byun(2023) Soil stabilization using Zeinbio polymer,(Compactiontest, CBRtestand permeability test)
5. PouyanBagheri,IvanGratcher(2023)EffectsofXanthanGumBiopolymer on Soil MechanicsProperties,(Unconfinedcompressivestrengthtest, Triaxial Test)
6. JayaprakashReddy,Varaprasad B.J.S(2020)EffectsofXanthangumbiopolymersondispersivepropertiesofsoils ,(UCS testand CBR test)
7. Keshav,Vasanth,andSudhirVummadiseti. "Non-rectangular plateswithirregularinitialimperfections subjectedtononlinearstaticanddynamic loads." *International JournalofAdvancesinEngineeringSciences andAppliedMathematics* 15,no.4(2023):155-158.
8. Vummadiseti, Sudhir, and S. B. Singh."The Influence of Cutout Location onthePostbucklingResponseofFunctionally GradedHybridCompositePlates."In *StabilityandFailureofHighPerformanceCompositeStructures*,pp.503-516.Singapore: Springer Nature Singapore,2022.
9. Sathi,KranthiVijaya,SudhirVummadiseti, andSrinivasKarri."EffectofhightemperatureonthebehaviourofRCCcolumnsincompression." *Materials Today:Proceedings*60 (2022): 481-487.
10. Vummadiseti, Sudhir, and S. B. Singh."Bucklingandpostbucklingresponse ofhybridcompositeplatesunderuniaxial compressive loading." *JournalofBuildingEngineering* 27(2020):101002.
11. Vummadiseti, Sudhir, and S. B. Singh."Postbuckling response of functionallygraded hybrid plates with cutouts underin-planeshearload." *JournalofBuildingEngineering* 33(2021):101530.
12. Vummadiseti,S.,andS.B.Singh."Boundary conditioneffectsonpostbucklingresponseof functionallygradedhybridcompositeplates. " *J.Struct. Eng. SERC* 47, no. 4 (2020): 1-17.
13. Singh,ShamsherBahadur,SudhirVummadiseti, and Himanshu Chawla."Developmentandcharacterisation of

- novel functionally graded hybrid of carbon-glass fibres." *International Journal of Materials Engineering Innovation* 11, no.3(2020):212-243.
14. Vummadisetti, Sudhir, and S.B. Singh. "Buckling and post buckling response of hybrid composite plates under uniaxial compressive loading." *Journal of Building Engineering* 27 (2020): 101002.
 15. Singh, S. B., Himanshu Chawla, and Sudhir Vummadisetti. "Experimental and Analytical Studies of Failure Characteristics of FRP Connections." In *Recent Advances in Structural Engineering, Volume 2: Select Proceedings of SEC2016*, pp. 755-757. Springer Singapore, 2019.
 16. Singh, S. B., Sudhir Vummadisetti, and Himanshu Chawla. "Assessment of interlaminar shear in fiber reinforced composite materials." *Journal of Structural Engineering* 46, no. 2 (2019): 146-153.
 17. Singh, S. B., Himanshu Chawla, and Sudhir Vummadisetti. "Experimental and Analytical Studies of Failure Characteristics of FRP Connections." In *Recent Advances in Structural Engineering, Volume 2: Select Proceedings of SEC2016*, pp. 755-757. Springer Singapore, 2019.
 18. Singh, S. B., Sudhir Vummadisetti, and Himanshu Chawla. "Influence of curing on the mechanical performance of FRP laminates." *Journal of Building Engineering* 16 (2018): 1-19.
 19. Rakesh, Pydi, Padmakar Maddala, Mudda Leela Priyanka, and Borigarla Barhmaiah. "Strength and behaviour of roller compacted concrete using crushed dust." (2021).
 20. Barhmaiah, Borigarla, M. Leela Priyanka, and M. Padmakar. "Strength analysis and validation of recycled aggregate concrete." *Materials Today: Proceedings* 37 (2021): 2312-2317.
 21. Padmakar, M., B. Barhmaiah, and M. Leela Priyanka. "Characteristic compressive strength of a geopolymer concrete." *Materials Today: Proceedings* 37 (2021): 2219-2222.
 22. Priyanka, Mudda Leela Leela, Maddala Padmakar, and Borigarla Barhmaiah. "Establishing the need for rural road development using QGIS and its estimation." *Materials Today: Proceedings* 37 (2021): 2228-2232.
 23. Srinivas, K., M. Padmakar, B. Barhmaiah, and S.K. Vijaya. "Effect of alkali activators on strength properties of metakaolin and fly ash based geopolymer concrete." *JCR* 7, no. 13 (2020): 2194-2204.
 24. Mathew, Rojeena, and M. Padmakar. "Defect development in KDP Crystals produced at severe Supersaturation."
 25. Sathi, Kranthi Vijaya, Sudhir Vummadisetti, and Srinivas Karri. "Effect of high temperature on the behaviour of RCC columns in compression." *Materials Today: Proceedings* 60 (2022): 481-487.
 26. Jagadeeswari, Kalla, Shaik Lal Mohiddin, Karri Srinivas, and Sathi Kranthi Vijaya. "Mechanical characterization of alkali activated GGB S based geopolymer concrete." (2021).
 27. Srinivas, Karri, Sathi Kranthi Vijaya, Kalla Jagadeeswari, and Shaik Lal Mohiddin. "Assessment of young's modulus of alkali activated ground granulated blast-furnace slag based geopolymer concrete with different mix proportions." (2021).
 28. Kalla, Jagadeeswari, Srinivas Karri, and Kranthi Vijaya Sathi. "Experimental analysis on modulus of elasticity of slag based

- concrete." *Materials Today: Proceedings* 37(2021): 2114-2120.
29. Srinivas, Karri, SathiKranthiVijaya, and KallaJagadeeswari. "Concrete with ceramic and granitewaste as coarse aggregate." *Materials Today: Proceedings* 37(2021): 2089-2092.
 30. Vijaya, SathiKranthi, KallaJagadeeswari, and KarriSrinivas. "Behaviour of M60 grade concrete by partial replacement of cement with fly ash, rice husk ash and silica fume." *Materials Today: Proceedings* 37(2021): 2104-2108.
 31. Mohiddin, Shaik Lal, Karri Srinivas, SathiKranthiVijaya, and KallaJagadeeswari. "Seismic behaviour of RCC buildings with and without floating columns." (2020).
 32. KranthiVijaya, S., K. Jagadeeswari, S. Lal Mohiddin, and K. Srinivas. "Stiffness determination of alkali activated ground granulated blast furnace slag based geo-polymer concrete." *Mater. Today Proc* (2020).
 33. Srinivas, K., M. Padmakar, B. Barhmaiah, and S. K. Vijaya. "Effect of alkali activators on strength properties of metakaolin and fly ash-based geopolymer concrete." *JCR* 7, no. 13 (2020): 2194-2204.
 34. Borigarla, Barhmaiah, and S. Moses Santhakumar. "Delay Models for Various Lane Assignments at Signalised Intersections in Heterogeneous Traffic Conditions." *Journal of The Institution of Engineers (India): Series A* 103, no. 4 (2022): 1041-1052.
 35. Barhmaiah, Borigarla, A. Chandrasekar, Tanala Ramya, and S. Moses Santhakumar. "Delay models for Signalised Intersections with Vehicle Actuated Controlled system in Heterogeneous Traffic Conditions." In *IOP Conference Series: Earth and Environmental Science*, vol. 1084, no. 1, p. 012038. IOP Publishing, 2022.
 36. Borigarla, Barhmaiah, Triveni Buddaha, and Pritam Hait. "Experimental study on replacing sand by M-Sand and quarry dust in rigid pavements." *Materials Today: Proceedings* 60 (2022): 658-667.
 37. Singh, Sandeep, Borigarla Barhmaiah, Ashith Kodavanji, and Moses Santhakumar. "Analysis of two-wheeler characteristics at signalised intersection under mixed traffic conditions: A case study of Tiruchirappalli city." In *13th Asia Pacific Transportation Development Conference*, pp. 35-43. Reston, VA: American Society of Civil Engineers, 2020.
 38. Brahmaiah, B., and A. Devi Prasad. "Study & Analysis of An Urban Bus and Metro Route Using Vissim Simulated Data." *International Journal of Latest Trends in Engineering and Technology* 8, no. 1 (2017): 406-412.
 39. Brahmaiah, B., M. Tech-IITR, A. D. Prasad, and K. Srinivas. "A Performance Analysis of Modelling Route Choice Behavior on Urban Bus and Multi Mode Transit Route." *Int. J. Adv. Inf. Sci, Technol* (2017): 11.
 40. Brahmaiah, B., and A. Devi Prasad. "PERFORMANCE ANALYSIS OF AN URBAN BUS AND METRO ROUTE USING COMMUTER SURVEY & TRAFFIC DATA.