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Studies on Strength Characteristics of Soil Mixed with Guar Gum

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Abstract: ***Natural biopolymers discussed as environmentally friendly and sustainable grouting chemicals. This paper presents guidelines for selecting potentially useful biopolymers for strengthening cohesion soil. Soil is a universally available natural material derived mostly from rocks and rocky minerals. As soil is a product of nature, possess an inherently variable and complex character. The load bearing capacity is the most important soil property, which governs the design of pavement Guar gum was identified for the study over a range of concentration (0.5%, 1.0%, 1.5%, 2.0%, 2.5%, and 3.0%). Experimental results of Expansive soil treated with various percentages of Guar gum gel for various water content and cured samples of 0, 3,7days. Strengthening effect of Guar gum was shown to have greatest effect on expansive soil with curing periods. Depending on biopolymer concentration, the unconfined compressive strength of expansive soil treated with Agar gum biopolymer. Unconfined compressive strength tests over a range of confining pressures also indicated that the biopolymers effectively increased the expansive soil intercept and CBR values of the treated expansive soil.***

Keywords: Ground improvement, Guar gum, Soaked-CBR, Un-confined compressive strength, Expansive soil

1. Introduction

In the present study, expansive soils are considered for effectiveness of biopolymer stabilization. As an alternative to such traditional soil treatment and improvement techniques, biological approaches are now being actively investigated in the field of geotechnical engineering, including microbe injection and by product precipitation. In particular, microbial induced polymers—or biopolymers—have been introduced as a new kind of construction binder, especially for soil treatment and improvement. To date, most studies on these applications of biopolymers have been experimental efforts that have produced preliminary findings and analyses, and the number of theoretical explanations and case studies of practical implementation in the literature are still limited. In response, this paper provides a detailed review of biopolymer applications in geotechnical engineering including the most recent studies. In this review, strengthening mechanisms between typical biopolymers and soils based on microscopic inter-particle interactions are summarized. The advantages and disadvantages of biopolymer applications are compared with those of existing soil engineering methods. Finally, the potential for practical implementation is evaluated via an economic feasibility analysis, including environment-friendly considerations.

There are different methods of stabilization, which include physical, chemical and polymer methods of stabilization. Physical methods involve physical processes to improve soil properties. This includes compaction methods and drainage. Compaction processes lead to increase in water resistance capacity of soil. Drainage is less common due to generally poor connection between method effectiveness and cost. But, compaction is very common method. Although, it makes soil more resistant to water, this resistance will be reducing over time. Chemical soil stabilization uses chemicals and emulsions as compaction aids, water repellents and binders. The most effective chemical soil stabilization is one which results in non-water-soluble and hard soil matrix. Polymer methods of stabilization have a number of significant advantages over physical and chemical methods. These polymers are cheaper and are more effective and drastically less dangerous for the environment as compared to many chemical solutions.

1.1 Objective of the Work

Biopolymers mix through soil, such like humid rice mortar, advance strengthening soil, as well as improved cohesion and strength, resistance to erosion, reduced permeability, etc., by acting the same as a binder. The straight utilize of biopolymers within soil have numerous benefits more than pre-existing genetic soil treatment methods. The direct use of Exo-cultivated biopolymers for soil remedy overcomes numerous shortcomings of other techniques (e.g., microbe injection) which include the want for microbial and nutrient injection, time for cultivation and excrement precipitation, and inappropriateness with clayey soils. Moreover, biopolymers are with ease originate within environment and many are acknowledged to be innocent and fit for human consumption, biopolymers can be taken into consideration green substitutes for soil remedy.

2. Previous Research Works

Ivanov and Chu (2008) Concluded the majority of the studies on Microbial Geo technology at present are at the laboratory stage. Two important applications, bio blockage along with bio cementation had been explored.

Dejong et al (2013) Observed that bio-induced mineralization in soils may reduce the pore space of soil and strengthen the particle contacts, leading to increased strength and decreased permeability and compressibility.

Chen and Zang (2013) Studied Xanthan gum and guar gum, biopolymers which can be obviously going on and cheaper, to stabilize mine tailings (MT). By evaluating undrained shear electricity statistics with empirical equations within literature, new equations had been proposed for predicting undrained shear strength MT blended with a biopolymer for water filling close to fluid restriction, based totally on the liquid restriction and water content, and the liquidity index.

Sharma et al (2008) Had studied on "The engineering behaviour of remoulded expansive clay blended with lime, calcium chloride and Rice-husk ash". They added amount of lime, calcium chloride and rice husk ash were varied from 0 to2%, 0 to 5% and 0 to 16%, respectively by the weight of natural soil. The effect of admixtures on unconfined strength and CBR was found. The UCC strength of natural soil improved up to 1% calcium chloride or 5% lime. The strength improvement in UCS of 225 and 328% was observed. A rice husk content of 12% was found to be the optimum for both the UCS and CBR. An optimum percent of calcium chloride and lime is 1% and 4% respectively.

Santhos and K. S. Beena (2016) Their paper "studies on strength characteristics of soil mixed with jarofix". The jarosite, a waste material produced during extraction of zinc ore is converted to jarofix. They added different percentage 10 to 50% of jarofix to natural soil and concluded that the 10% of jarofix is showed a better improvement in unconfined compressive strength. The natural soil having a UCS of 150 kN/m2 and after 7 days strength with 10% additive the strength may increased to 320 kN/m2.

AshutoshRawat (2017) Studied on "Improvement of CBR and Compaction Characteristics of Expansive Soil Using Lime and Blast Furnace Slag". They added lime and furnace slag to soil and concluded that the California bearing Ratio was observed to be about 11.41% for soil mixed with 2% lime and 20% Blast Furnace Slag mixture. While the value of CBR for soil mixed with 50% BFS only is 8.74. Means it proves that the addition of BFS in soil is more advantageous when mixed with lime in association to BFS mixed only to soil. Firstly the CBR value of soil is 2.37% which get enhanced up to 11.41% at optimum percentage i.e. the 2% lime with 20% Blast Furnace Slag.

3. Materials and Experimental Investigation

3.1 Expansive Soil

Expansive soil is a type of clay that is known as a light weight aggregate with a rounded structure, with a porous inner and a resistant and hard outer layer. It is soils that are chance to large volume changes (swelling and shrinkage) that are directly related to water content can form deep cracks in summer seasons. Such soils are called vertisoils with smectite clay minerals like montmorillonoite and bentonite, have the most dramatic shrink-swell capacity. Expansion of soils tends to be exert enough force on a buildings or roads pavements or other structures to cause serious damages.

The soil used in this investigation the expansive soil collected from the Thadigotla village area, near Krishnapuram, Kadapa, A.P, India. The pebbles and vegetative matter present at the site are removed by hand. The soil is collected at 1.0m depth below the natural ground level. It is dried and pulverized and sieved through a sieve of 4.75 mm size to eliminate gravel fraction, if any. This dried and sieved soil is stored in airtight containers ready for use for mixing. The soil is classified as 'CH' as per I.S. classification (I.S. 1498:1978) indicating that it is Inorganic Clay of High Plasticity. Its degree of expansiveness is very high as the Differential Free Swell Index (DFSI) is 140 per cent.

Table 3.1: Physical properties of Expansive soil

S. No	Properties of the soil	Details
1.	Grain size distribution:	
	(a) sand	14%
	(b) silt	22%
	(c) Clay	64%
2.	Atterberg Limits:	
	(A) Liquid Limit	72%
	(B) Plastic Limit	39%
	(C) Plasticity Index	38%
3.	IS Classification	CH
4.	Differential Free Swell Index	78.95%
5.	Specific Gravity	2.43
6.	Compaction Characteristics	
	(A) Maximum Dry Unit Weight	1.45g/cc
	(B) Optimum Moisture Content	23.67%
7.	California Bearing Ratio Value	2.39%
8.	Unconfined Compressive Strength	1.02kg/cm^2

3.2 Guar gum

The Guar or cluster bean (CyamopsisTetragonoloba) is an annual legume and the source of Guar gum. It is also known as Gavar, Guwar or Guvar bean. Few agriculturists in semi-arid regions use guar as a source to replenish the soil withessential fertilizers and nitrogen fixation, before the next crop. Guar as a plant has a multitude of different functions for human and animal nutrition but its gelling agent containing seeds (Guar gum) are today the most important use. This was added with dispersive soil and pond ash in different percentages (0.5%, 1%, 1.5%, 2.0%, 2.5% and 3%).

Table 3.2: Properties of Guar gum

S.No	Contents	Details
1	Physical state	Dry, cream-colored powder
2	Moisture (%)	8-15%
3	Ash	7-12%
4	Nitrogen	0.3-1.0%
5	Acetate content	1.9-6.0%
6	Pyruvate content	1.0-5.7%
7	Monovalent salt	3.6-14.3%
8	Divalent salt	0.085-0.17%
9	Viscosity	13.35

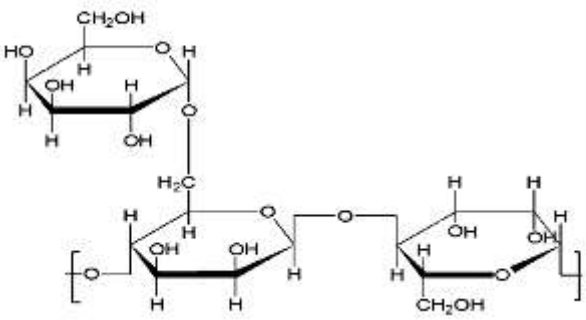

Figure 3.1: Idealized structure of guar gum.

Figure 3.2: Guar gum

Guar gum molecules are neutral. Similarly to other biopolymers, they are often chemically modified by simple methods, due to presence of reactive groups in their structure. The functionalized species, with altered properties, may be neutral or charged. One derivative of guar gum is guar 2-hydroxy-3-(trimethylammonio)propyl 10 ether chloride (cationic guar gum), modified with a quaternary ammonium cations.

3.3 Procedure for mixing

The soil sample kept ready to mixed with anhydrous guar gum powder of varying percentages are varied from 0.0 to 3.0% by the weight of the soil, in increment 0.5% per cent. The soil and guar gum powder are mixed thoroughly and is used for the test.

4. Experimental Investigations

The Black Cotton soil has been a challenge to geotechnical and highway engineers. In the present work, an attempt was made by using guar gum as stabilization material in expansive soil. In this investigation different laboratory experiments like Atterberg limits, differential free swell, unconfined compressive strength, soaked CBR tests conducted on stabilized expansive soil with guar gum in varying percentages of 0.5%, 1.0%, 1.5%, 2.0%, 2.5% & 3.0% of to the expansive soil.

The experimental programmes are broadly divided into six categories, viz.

1. Atterberg limits
2. Differential Free Swell Index
3. Compaction characteristics
4. California Bearing Ratio Values
5. Strength characteristics and
6. SEM analysis

5. Results and Discussions

General

The results derived from the various experiments were presented in both tabular form as well as graphical form and subsequently discussed. the main objective of the this study is to assess the applicability of soil chemical stabilization, with respect to the density, moisture content, unconfined compressive strength and California bearing ratio value..

5.1 Plasticity Characteristics

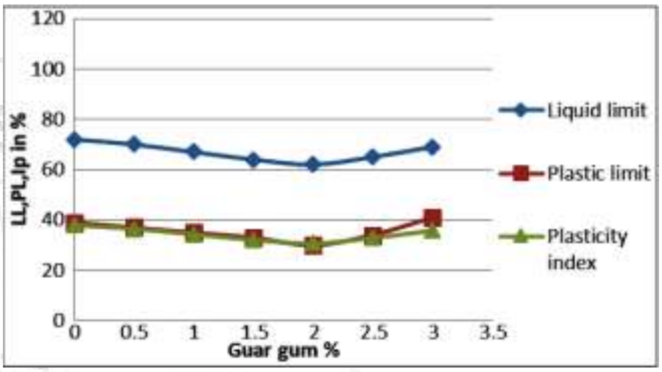

Figure 5.1: Plasticity Characteristics of guar gum Admixed Soil

When guar gum reacts with wet soils, it alters the nature of the adsorbed layer. Ions replace the sodium or iodine ions. The double layer is usually depressed due to an increase in the cation concentration. Hence, in guar gum stabilization, the liquid limit and plastic limit of the soil decreases. Thus, the plasticity index of the soil decreases, the soil becomes more friable and workable. There is reduction in Liquid limit of soil with addition of guar gum up to the incremental percentage of 2.0% beyond this it has been observed that there is increase in Liquid limit. Same trend of effect of guar gum observed in case of Plastic Limit values also like as incase of LL. The influence of guar gum on Plasticity Index of soil is considerable up to the 2.0% guar gum admixed soil.

5.2 Compaction Characteristics

Standard Proctor's compaction tests are carried out on black cotton soil admixed with guar gum at various percentages ranging from 0.0% to 3.0% by weight of the soil in increment of 0.5%. But the Dry density goes on increase from 0.0% to 2.0%, after the 2.0% the dry density trend goes on decrease with increase in guar gum percentage. From the test results Optimum Moisture content decreases and Maximum Dry Density values are increases up to 2.0% of guar gum.

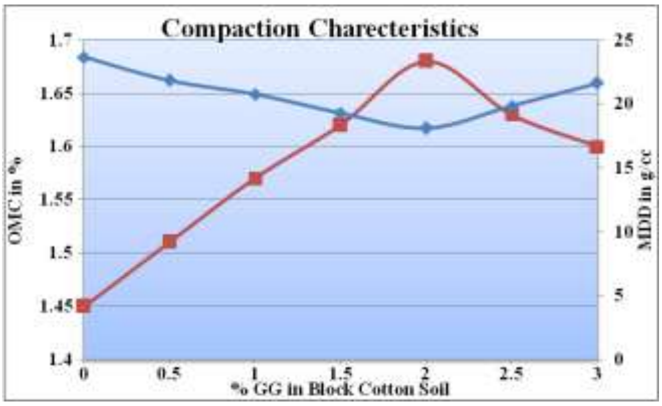

Figure 5.2: GG % Vs OMC cum MDD

5.2.1 Optimum Moisture Content

Fig 5.2 Depicts the relationship between the optimum moisture content verses percentage of guar gum by the weight of soil, the decreasing in water content with the increase in guar gum percentage up to 2.0%, but beyond this increase in guar gum causes more amount of moisture content requirement to achieve max dry density corresponds to that moisture content.

5.2.2 Maximum Dry Density

The relationship between the maximum dry density and GG percentage by the weight of soil. the increasing in maximum dry density of 1.68 g/cc up to 2.0% of biopolymer, Excess percentage of the GG the dry density value may be decreasing for 2.5% and 3.0%. Hence, it is concluded that the 2.0% 0f biopolymer is gives the maximum dry density i.e., 1.68g/cc. water content is 18.10%.

5.2.3 California Bearing Ratio

The CBR value of soil samples admixed with GG increase with increase in percentages of GG up to 2.0% and It is found that the excess of GG more than 2.0% causes decrease in CBR value. Because of reactions and basic nature of Biopolymer it transformed into a lumps when it is mixed with corresponding water content. So that, excess percent of guar gum results in decrease in CBR value.

Table 5.1: Un-soaked & Soaked CBR Values of Expansive soil sample with varied % of Guar gum.

Sl. No	% Of Guar Gum	Un-soaked	soaked
1	**0.0% GG**	2.39	1.96
2	**0.5% GG**	3.50	2.76
3	**1.0% GG**	4.78	3.76
4	**1.5% GG**	5.46	4.44
5	**2.0% GG**	7.60	5.21
6	**2.5% GG**	5.81	4.35
7	**3.0% GG**	5.29	3.93

5.3 Unconfined Strength characteristics

The unconfined compressive strength value of soil samples admixed with GG increase with increase in

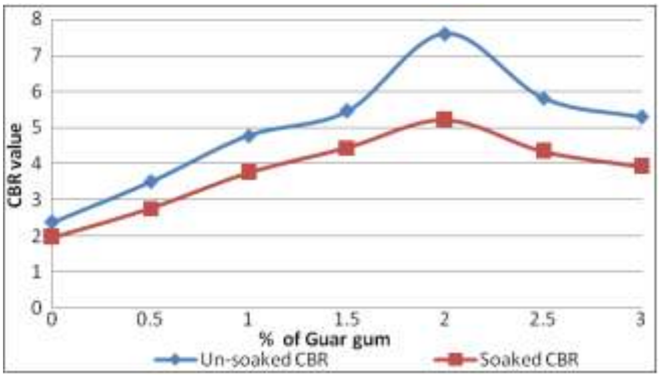

Figure 5.3: CBR Of Soil With GG Vs % of GG in Un-Soaked And Soaked conditions

Percentages of GG up to 2.0% and It is found that the excess of GG more than 2.0% causes decrease in strength value. Because of reactions and basic nature of Biopolymer it transformed into a lumps when it is mixed with corresponding water content. So that, excess percent of guar gum results in decrease in unconfined compressive strength value.

Table 5.2: UCC Strength at different Curing Periods of Guar gum admixed Soil

Sl. No	*% Of GG*	*UCC Strength in Kg/cm^2 at different Curing Periods*		
		0 DAY	*3 DAYS*	*7 DAYS*
1	**0.00**	1.02	1.08	1.201
2	**0.50**	1.37	1.48	1.78
3	**1.00**	1.51	1.74	1.91
4	**1.50**	1.90	2.03	2.20
5	**2.00**	2.24	2.51	2.72
6	**2.50**	1.93	2.17	2.41
7	**3.00**	1.61	1.78	2.10

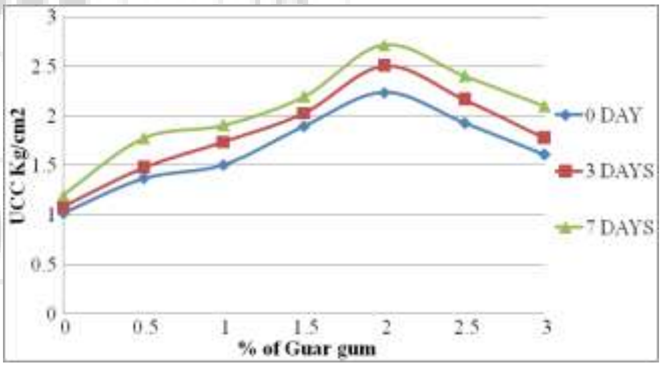

Figure 5.4: Un-Confined Compressive Strength Vs % of GG

6. SEM Analysis

From the SEM analysis the increase in guar gum percentage in the soil sample changes amorphous structure from crystalline structure of natural soil.

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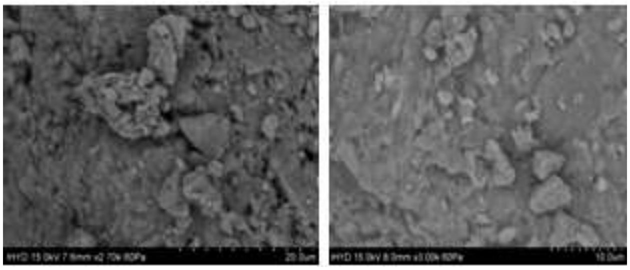

Figure 5.3: SEM analysis Images of guar gum admixed soil 0% and 2.0%

7. Conclusions

1) There is reduction in Liquid limit of soil with addition of Guar gum up to the incremental percentage of 2.0% beyond this it has been observed that there is increase in Liquid limit, because of reaction between soil and biopolymer mixer converted into lumps form.
2) With increasing proportion guar gum, liquid limit values are decreased from 72% to 62% with proportion decrease is 13.89%.
3) With increasing proportion of guar Gum, the plastic Limit values are decreased 39% to 30.66% with proportion decrease is 23.08%.
4) With increasing proportion of guar Gum, the Plasticity Index values are decreased from 37.96% to 30.66% and the percentage decreased is 19.23%.
5) The maximum dry density of untreated soil to 2.0% of biopolymer treated soil is increases from 1.45 g/cc to 1.68 g/cc. There is reduction in optimum moisture content with per cent increase in guar gum by weight of the soil up to 2.0%.
6) The optimum moisture content for natural expansive soil is 23.67% and for 2.0% guar gum treated soil is 18.10%. The decrement decrease of moisture content up to 2.0% of guar gum. Beyond the 2.0% guar gum viz, 2.5 and 3.0% of biopolymer the water contents may be increases.
7) The California Bearing Ratio value of the soil is influenced by the addition of guar gum. The maximum increase in California Bearing Ratio value of soil admixed with guar gum which occurs at 2.0%.
8) The un-soaked CBR value of soil with 0.5 to 2.0% of guar gum admixed soil showed an increment of 46 to 217%. Whereas 2.5% of biopolymer admixed soil shows an increment of 143%.
9) The soaked CBR values for soil with 0.5 to 2.0% of guar gum admixed soil showed an increment of 40 to 165%. Beyond the 2.0% guar gum per cent the soaked CBR values decreased. The maximum un-soaked CBR value of 2.0% guar gum admixed soil is 3.2 times that of the natural expansive soil.
10) The strength of soil samples admixed with guar gum tested immediately increase with increase in per cent of guar gum. The unconfined compressive strength of the admixed soil increases with in biopolymer percentage and curing period.
11) The unconfined compressive strength of natural soil is 1.02 kg/cm2 in all curing days. 3 days and 7days curing strengths of 2.0% biopolymer treated soil is 2.51 kg/cm2 and 2.72 kg/cm2 respectively.
12) The Unconfined compressive strength of admixed soil at 2.0% biopolymer for the sample tested with 7 days curing period is 2.6 times that the Unconfined Compressive strength of the natural soil.

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