Revamping effects of Guar gum and Xantham gum on engineering properties of expansive soil.

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Abstract: In geotechnical engineering, soil stabilization provides practical and effective solutions. In this study expansive soil from Bhavnagar city, Gujarat is being used for soil stabilization. Soil stabilization of expansive soil is necessary because it undergoes significant volume changes when it absorbs water soil swells and shrinks when it is dried. In this research work two different bio-polymer is been used called as guar gum and xantham gum. Both the bio-polymer is organic and environment friendly. Here the high plastic clay is been treated for varying concentrations of (0.5%,1%,1.5% and 2%) for both bio-polymer by its dry soil mass. This works focuses on tests like Modified proctor test and unconfined compressive strength.

Keywords: Soil Stabilization, Expansive soil, Guar gum, Xantham gum, Unconfined Compressive Strength.

1. Introduction:

Traditional chemical impurities such as lime, cement, bitumen materials, flying ash, calcium and carbides are widely used in construction. These additives are evaluated for their ability to increase properties such as resistance, sustainability, performance, hydraulic performance, and all for reasonable costs. These materials are found in nature or in the product as a result of natural processes. Meanwhile, biopolymers such as chitosan, sodium alginate, beta-glucan and Xantham gum provide alternatives to the usual mixtures for use as soil stabilizers. They are used in areas such as bio-mediation, attenuation of liquefaction, prevention of erosion, stabilizing slopes, and strengthening weak soils.

Many studies have studied the effectiveness of biopolymers in improving the geological properties of different types of soils. For example, studies have shown that the addition of guar gum increases the stability of the soil unit and minimizes erosion. In the same way, it has been found that Xantham gum improves rheological characteristics and erosion resistance in fried clay soils. Other studies show that the injection of guar gum in the locusts considerably increases its resistance to compression when it is reduced permeability. Xantham Gum depending on its concentration, increases its elastic module and resistance to soil heat delays, indicating its potential as an effective soil stabilizer.

2. Materials:

2.1 Soil:

Expansive Soil was collected from Kaliyabid region, Bhavnagar, Gujarat. The soil was approximately collected below 1m to the ground surface. It was done to prevent collecting the aggregates or any organic materials. The soil is blackish-brown in color.

Specific Gravity	2.67
Liquid limit (%)	58
Plastic limit (%)	31
Optimum moisture content (%)	16.6
Maximum dry density (gm/cc)	1.845

TABLE 1. SOIL PROPERTIES

2.2 Guar Gum:

Guar gum, derived from the endosperm of guar seeds (*Cyamopsis tetragonolobus*), is a high molecular weight biopolymer belonging to the polysaccharide group. Known for its excellent stabilizing capabilities, it also significantly enhances viscosity. It’s remarkable binding properties and strong chemical bonds facilitate the formation of cohesive gels. These gelling and binding characteristics make it highly effective for modifying soil properties. (Devika Usha S, 2024).

FIG.1 GUAR GUM

2.3 Xantham Gum:

Xanthan gum is a polysaccharide widely used as a food additive and rheology modifier. It is synthesized through the fermentation of glucose or sucrose by the bacterium *Xanthomonas campestris* (Davidson, 1980; Rosalam, 2006). This negatively charged polysaccharide consists of various components, including D-uronic acid, D-mannose, pyruvylated mannose, 6-O-acetyl D-mannose, and 1,4-linked glucan (Cadmus, 1982). Its chemical formula, $C_{35}H_{49}O_{29}$, reflects a linear β-D-glucose backbone with a trisaccharide side chain attached to every alternate glucose unit. The alignment of the side chain with the backbone creates stability and supports the molecule's overall structure through hydrogen bonding.

FIG.2 XANTHAM GUM

3. METHODS:

3.1 Sample preparation:

All soil was dried in an oven at 105 °C for at least 24 h before experimental procedures. Two types of biopolymers guar gum and xantham gum were selected for stabilization. The specimens were treated with the biopolymers at four varying concentrations (0.5%, 1%, 1.5% and 2%) by dry weight of soil. In order to prepare the specimens, firstly the biopolymer was mixed the soil. The main study objectives will be obtained by the application of the Atterberg limit, Modified compaction test and unconfined compressive strength test.77

FIG.4 PLASTIC LIMIT

FIG.5 LIQUID LIMIT

FIG.6 EXTRUDED SAMPLE AFTER COMPACTION TEST

FIG.7 UCS SAMPLE

4. RESULTS:

It was possible to assess the value of Guar Gum and Xantham Gum at several percentages (0.5%, 1%, 1.5%, and 2% by weight of dry soil) by looking at the particular soil parameter. The study's results are as follows: thorough examination of the impacts of biopolymers on the properties of soil. Given that the results demonstrated notable improvements in soil qualities, guar gum and xantham gum may be given to the soil as supplements. These findings suggest that using biopolymers in soil management strategies is crucial as they may enhance soil quality and promote sustainable practices. Table 2 displays the study's primary findings.

		0.5% GG	**1% GG**	**1.5% GG**	**2% GG**	**0.5% XG**	**1% XG**	**1.5% XG**	**2% XG**
LL (%)		91	108	136	142	91.5	97	99	111.5
PL (%)		51	57	77	72	53	75	82	87.5
OMC (%)		17.7	19.6	19.8	20.4	18.4	19.8	19.6	20.4
MDD (gm/cc)		1.84	1.78	1.75	1.72	1.795	1.76	1.75	1.72
UCS (N/mm2)	0 DAYS	0.643	0.461	0.371	0.280	0.323	0.386	0.336	0.254
	3 DAYS	0.805	1.188	1.660	1.650	1.887	2.343	3.230	3.678
	7 DAYS	1.484	1.561	2.377	2.035	1.947	2.651	3.441	3.995

TABLE 2 TEST RESULTS

4.1 ATTERBERG'S LIMIT:

As they are sustainable and naturally occurring, Guar gum and Xantham gum were utilized as stabilizers. Guar gum and Xantham gum levels increase the treated soil's liquid and plastic limit, because Xantham gum and Guar gum become activated and create hydrogels, this hydrogen bonds enhance bonding activity. On comparing untreated soil to treated soil with Guar gum and Xantham gum liquid limit increases significantly. Liquid limit increases from 58 % to 91%, 108%, 136% and 141% for 0.5%, 1%, 1.5% and 2% addition of Guar gum and 58% to 91.5%, 97%, 99% and112% for 0.5%, 1%, 1.5% and 2% addition of Xantham gum.

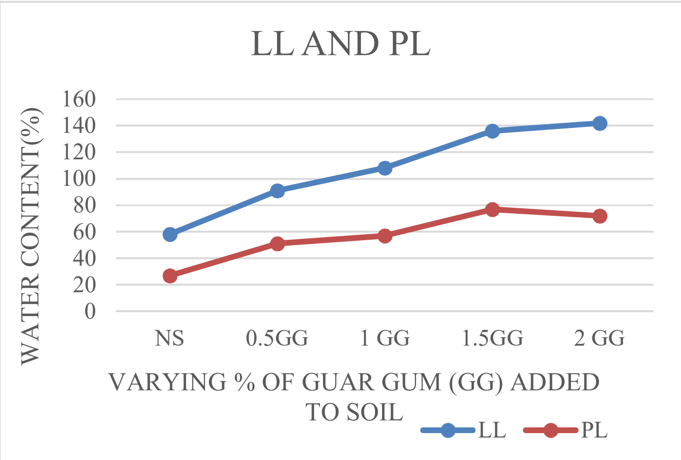

FIG 8(A) LIQUID LIMIT AND PLASTIC LIMIT OF GUAR GUM TREATED SOIL

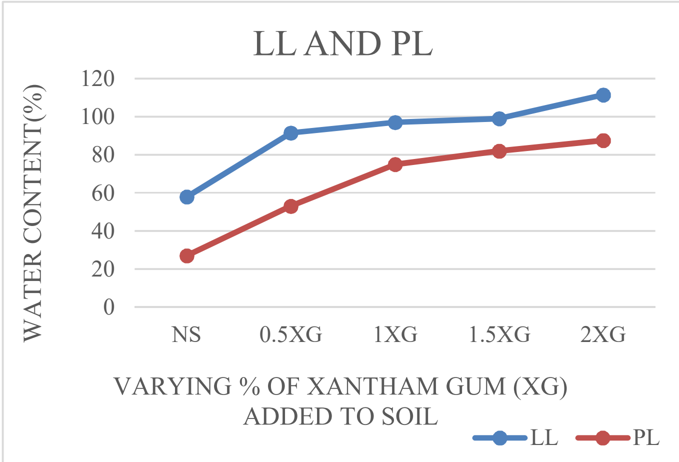

FIG 8(B) LIQUID LIMIT AND PLASTIC LIMIT OF XANTHAM GUM TREATED SOIL

(NS: Natural soil, GG: Guar gum, XG: Xantham gum)

4.2 COMPACTION CHARACTERISTICS:

Dry density and moisture content are important characteristics of soil. Here, Modified proctor test was performed on untreated soil and soil treated with different percentages of biopolymer. Modified proctor test gives the maximum dry density value at lower moisture content compared to standard proctor test which gives maximum dry density with high value of moisture content. Here, the OMC increases with increase in Guar gum and Xantham gum percentage and MDD values decreases with increase in Guar gum and Xantham gum percentage. MDD value decreases due to increase in water content in soil. OMC of untreated soil is 16.6% whereas OMC of Guar gum treated soil increases to 17.7%, 19.6%, 19.8% and 20.4% for 0.5%, 1%, 1.5% and 2% addition of Guar gum and OMC of Xantham gum treated soil increases to 18.4%, 19.8% ,19.4% and 20.4% for 0.5%, 1%, 1.5% and 2% addition of Xantham gum. MDD value of Guar gum treated soil decreases to 1.84, 1.78, 1.75 and 1.72 gm/cc for 0.5%, 1%, 1.5% and 2% addition of Guar gum and MDD value of Xantham gum treated soil decreases to 1.795, 1.76, 1.75 and 1.72 gm/cc for 0.5%, 1%, 1.5% and 2% addition of Xantham gum.

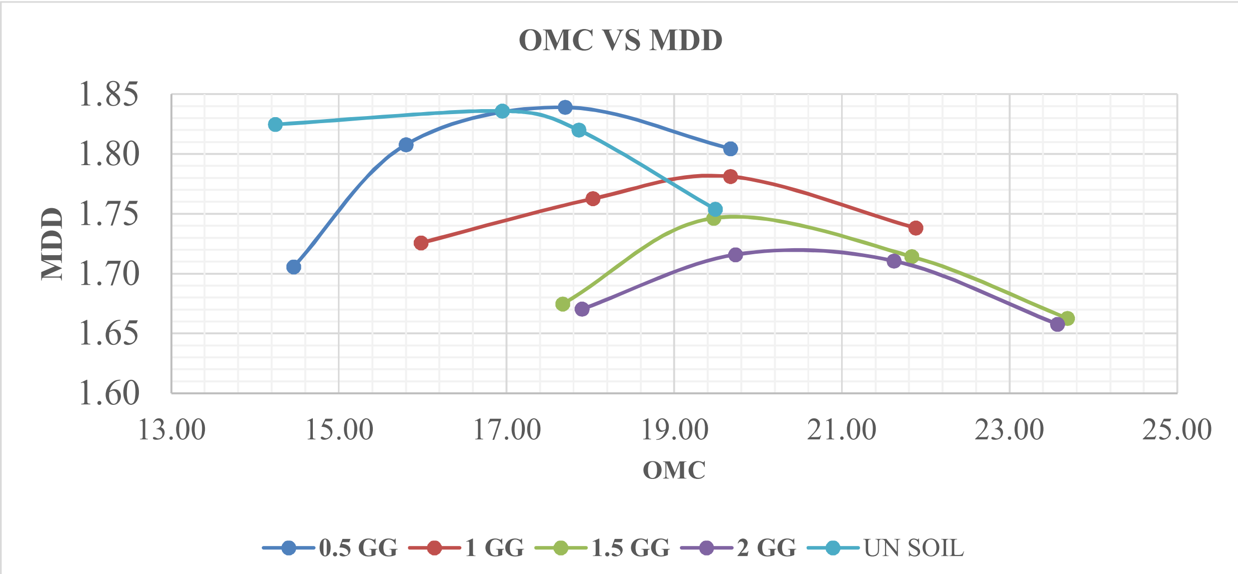

FIG 9. OMC VS MDD GUAR GUM TREATED SOIL

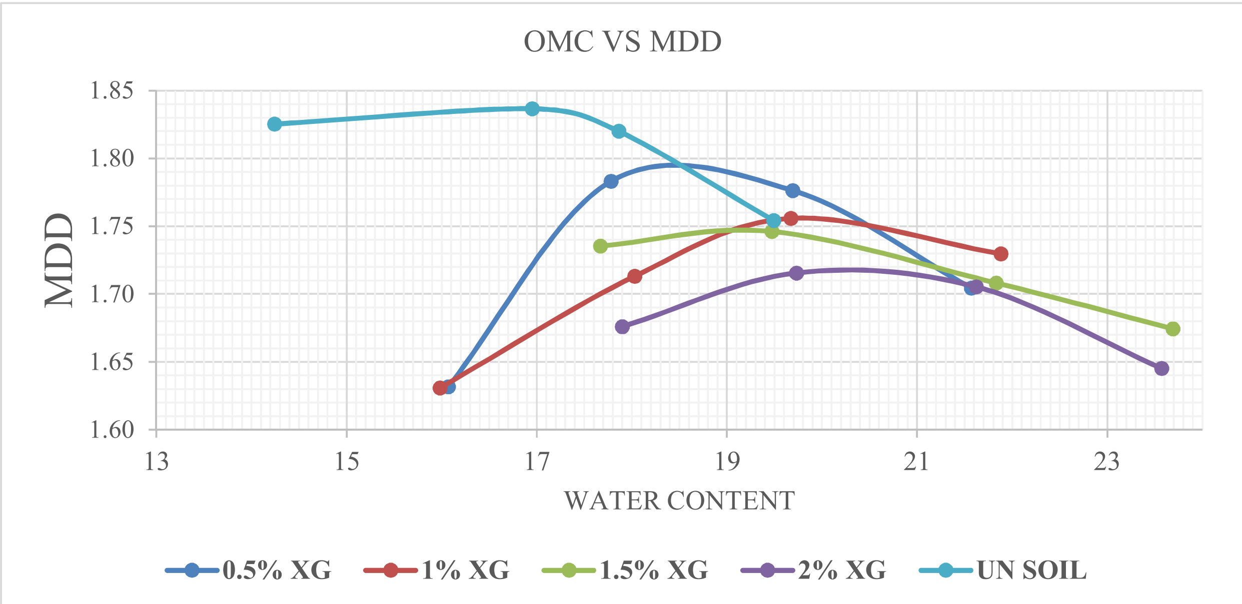

FIG 10. OMC VS MDD XANTHAM GUM TREATED SOIL

4.3 UNCONFINED COMPRESSION TEST:

Unconfined compression test is a test in which soil sample is loaded at rate of 1.25mm/min and the sample size are 38 mm diameter and 76 mm height. The load is applied till the sample fails. The value at which the sample fails is the maximum compression strength of the soil. Here total 81 samples were prepared for compression test, 3 sample for different percentage of biopolymer treated soil and 3 sample of untreated soil and the average value was calculated. The samples were cured for 0, 3 and 7 days. The maximum UCS values for untreated soil are 0.420 N/mm^2, 0.649 N/mm^2 and 0.762 N/mm^2 for 0, 3 and 7 days. The maximum UCS value was obtained for 1.5% guar gum treated soil was 0.371 N/mm^2, 1.660 N/mm^2 and 2.377 N/mm^2 for 0, 3 and 7 days and for 2% xantham gum treated soil was 0.254 N/mm^2, 3.678 N/mm^2 and 3.995 N/mm^2 for 0, 3 and 7 days. Figure 9 and Figure 10 shows average values of UCS for different dosage of Guar gum and Xantham gum.

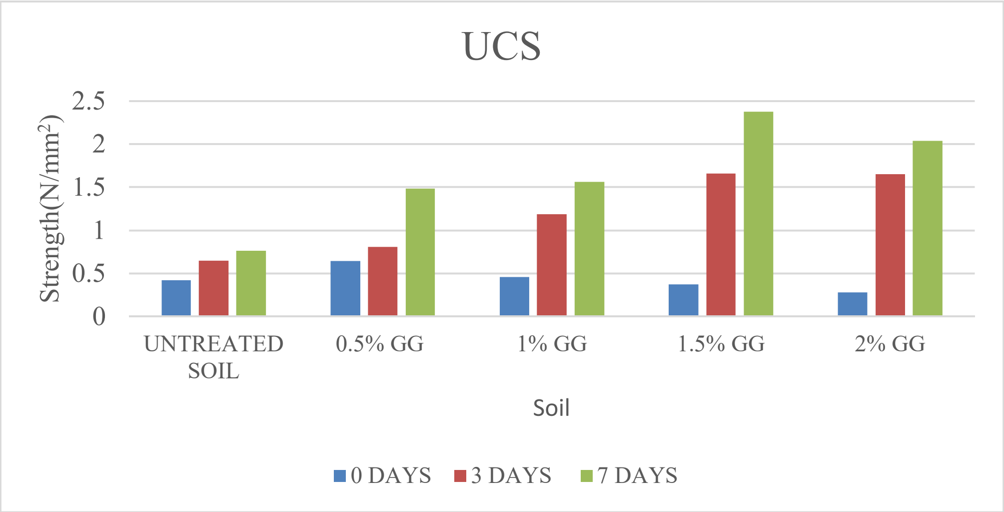

FIG 9. UCS VALUES FOR GUAR GUM TREATED SOIL

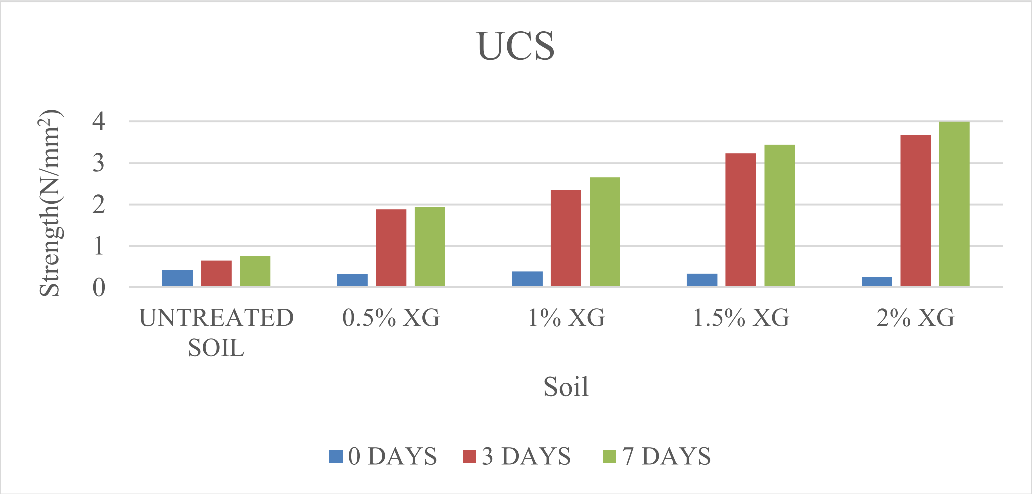

FIG 10. UCS VALUES FOR XANTHAM GUM TREATED SOIL

5.CONCLUSION:

- Liquid limit of soil with 0.5%, 1%, 1.5%, and 2% guar gum treated soil increased by 1.5 times, 1.85 times, 2.3 times and 2.4 times compared to untreated soil and with 0.5%, 1%, 1.5%, and 2% xantham gum treated soil increased by 1.55 times, 1.7 times, 1.7 times and 1.9 times compared to untreated soil.
- Plastic limit of soil with 0.5%, 1%, 1.5%, and 2% guar gum treated soil increased by 1.6 times, 1.8 times, 2.5 times and 2.3 times compared to untreated soil and with 0.5%, 1%, 1.5%, and 2% xantham gum treated soil increased by 1.7 times, 2.4 times, 2.6 times and 2.8 times compared to untreated soil.
- Maximum dry density decreases by 0.271%, 3.5%, 5.2% and 6.75% with 0.5%, 1%, 1.5% and 2% guar gum treated soil compared to untreated soil.
- Maximum dry density decreases by 2.7%, 4.6%, 5.14% and 6.5% with 0.5%, 1%, 1.5% and 2% xantham gum treated soil compared to untreated soil.
- Maximum UCS value was obtained at 1.5% guar gum treated soil which was 0.8 times, 2.5 times and 3.2 times compared to untreated soil at 0, 3 and 7 days of curing.
- Maximum UCS value was obtained at 2% xantham gum treated soil which was 0.6 times, 5.6 times and 5.25 times compared to untreated soil at 0, 3 and 7 days of curing.

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