STABILIZATION OF EXPANSIVE SOIL USING XANTHAN GUM

Suresh K, Professor and Head DCE, Nalla Malla Reddy Engineering College. Divya Nagar Hyderabad, T.S., INDIA
B Sunitha, Department of civil Engineering J.N.T. University, Hyderabad, 500072, Telangana, India

Abstract: In this paper Xanthan gum is used in the mechanical stabilization of expansive soils. Xanthan gum is polysaccharide used as a food additive and rheology modifier. This biopolymer is mixed with expansive soil in different proportions such as 0.02%, 0.03%, 0.04%, 0.05% and 0.06% by weight of dry soil. A series of laboratory tests like grain size distribution, specific gravity, free sell index, plastic limit, liquid limit, compaction, and California bearing ratio (CBR) are conducted on black cotton soil mixed with Xanthan gum and results are compared with standard engineering results. Hence the aim of the study is to review on the stabilization of black cotton soil using Xanthan gum as it helps in improving soil behavior.

KEYWORDS: Expansive Soils, Stabilization, Engineering Properties, Xanthan gum

1.0 INTRODUCTION

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

Xanthan gum utilized in this project is brought from a store .Xanthan gum may be a polysaccharide with many industrial uses, including as a standard artificial additive. The overall aim of soil treatment in construction engineering is to enhance soil properties like aggregate stability, strength, and erosion resistance. Conventional soil treatment materials have several shortcomings, especially from an environmental standpoint. As a result, an appropriate eco-friendly replacement for conventional materials is required. It's been used as a soil improvement material within the present study and experimental tests were performed with differing types of soils. The results show that the Xanthan gum fibers interact directly with the charged surfaces of clayey particles while forming Xanthan matrices that resemble a tough plastic between uncharged particles. Consequently, the strengthening effect of Xanthan gum was shown to possess the best efficiency with well graded soils with fine particles. Through experiments with varying concentrations of Xanthan gum, it had been found that the strengthening effect leveled off at higher concentrations. The strengthening effect was also shown to be greatly hooked in to the hydration level of the soils. Overall, the strengthening effect of Xanthan gum is shown to be hooked in to four factors: sort of soil, hydration level (e.g., moisture content), Xanthan gum content, and mixing method. This project prescribes the appropriate type of additives to be used with black cotton soils type, procedure for determining a design treatment level for each type of additive, and recommended construction practice for incorporating the additives into soils. The long –term performance of any construction project depends on the soundness of the underlying soils. Unstable soils are always a trencher and can create significant problems for pavements or structures. Indeed, the structural strength of stabilized soils can be factored into pavement designs. Stabilizers can be used to treat soils to varying degrees, depending upon the objective. The least amount of treatment is used to dry and temporarily modify soils. Such treatment produces a working platform for construction or temporary roads. Before beginning any construction project, project plans and specifications must be developed. For highway pavements, the design must accommodate expected traffic volume along with environmental, site and material conditions. So the main scope of transportation system has developed very largely. Population of the country is increasing day by day. While the above development in public transport sector was taking lace, the development in private transport was at a much faster rate mainly because of its advantages like accessibility, privacy, flexibility, convenience and comfort. This lead to the increase in vehicular traffic especially in private transport network. The objective of this project is to evaluate the strength behaviour of soil with natural biopolymers, and to determine the effect of the biopolymer stabilizers on engineering properties of expansive soils. Unconfined compressive strength and California Bearing Ratio (CBR) of biopolymersoil specimen is measured. The biopolymers used are Xanthan Gum with concentration of (0.02%, 0.03%, 0.04%, 0.05% & 0.06%) by weight of dry soil.

2. MATERIALS AND METHODOLOGY

Stabilization is that the process of blending and mixing materials with a soil to enhance certain properties of the soil. The method may include the Blending of soils to realize a desired gradation, texture or plasticity, or act as a binder for cementation of the soil. The method of reducing plasticity and improving the feel of a soil is named soil modification. Monovalent cations like sodium and potassium are commonly found in expansive clay soil and these cations are often exchanged with cations of upper valencies like calcium which are found in xanthan gum. Thus natural process process takes place almost rapidly, within a couple of hours. The calcium cations replace the sodium cations round the clay particles, decreasing the dimensions of bound water layer, and enable the Clay particles to flocculate. The flocculation creates a discount in plasticity, a rise in shear strength of clayey soil and improvement in texture from a cohesive material to more granular, sand like soil. The change within the structure causes a decrease within the moisture sensitivity and increase the workability and constructability of soil. Soil stabilization includes the consequences from modification with a big additional strength.

2.1 LAB TESTING

The tests were performed as per procedures described in IS code 2720-10. The various tests conducted on the sample are the subsequent

1. Atterburgs Limits.
2. Relative Density.
3. Free Swell Test.
4. Standard Proctor Test.
5. CBR Test.

Firstly the above tests were conducted on the plane black cotton soil samples to work out its properties. Compaction and CBR test are conducted to evaluate its strength. Thereafter, certain percentage of xanthan gum is added to the clay sample to stabilize it. And therefore the percentages of the above additives which produce the optimum strength to the soil are chosen by conducting test on them.

2.2 RESEARCH MATERIALS

Soil preparation: The soil was collected from site in large sacks from agricultural field near main highway at medchal district and also from farming field near Gundlapochampally village at medchal district. It delivered to the lab and is dried in oven for twenty-four hours in large pans. The soil observes a lot of water formed big lumps which is broken to smaller pieces or maybe fine powder and is sieved consistent with the requirements of various experiments to make it free from roots, pebbles, gravel etc.

Fig1: Black Cotton Soil

2.2.1 Black cotton soil: The black cotton utilized in this project is collected from a farming field in Gundlapochampally and also from a field near highway road in Medchal, up to a depth of 1.5m from the bottom level. The collected sample is then carried to geo technical engineering lab of CMRCET. The soil is then pulverized into small grains and kept in oven for 24hours.The essential experiments conducted for this dry black cotton soil are relative density, sieve analysis and Atterburg limits. Supported the results of sieve analysis liquid limit (LL), plastic Limit (PL), the natural soil is assessed as per IS classification. The results obtained are discussed within the next chapter.

2.2.2 Xanthan gum: This anionic polysaccharide is produced by the bacteria Xanthomonas campestris. Xanthan gum's negative charge comes from its carboxylic acid (-COOH) groups, since hydrogen atoms easily dissociate from these carboxylic acid groups to form carboxylate (-COO−) anions. Xanthan gum can also form hydrogen bonds with its numerous hydroxyl (- OH) groups. Small amounts of xanthan gum significantly increase an aqueous system's viscosity, which makes it a commonly used commercial substance. However, since the xanthan gum solution is pseudoplastic, its viscosity decreases with an increased shear rate. Xanthan gum also forms a viscous hydrocolloid when mixed with water, so it can also be considered dissolved in water.

Chemical formula ---- $C_{35}H_{49}O_{29}$

- **Chemical composition and structure** -- Xanthan is a long-chain polysaccharide having d-glucose, d-mannose, and d-glucuronic acid as building blocks in a molecular ratio of 3:3:2 with a high number of trisaccharide side chains. Xanthan gum has an average molecular weight of about 2000 kDa
- Xanthan gum is a sugar derived typically from corn (can also be from wheat) that has been pooped out by a bacteria that produces rot on various vegetables.
- The product is a gummy substance (hence the name) that is then dehydrated and ground into powder

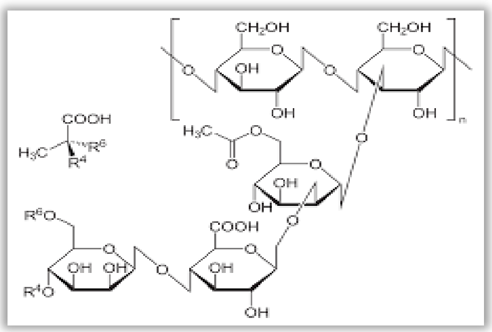


Fig2 : Chemical Structure of Xanthan Gum

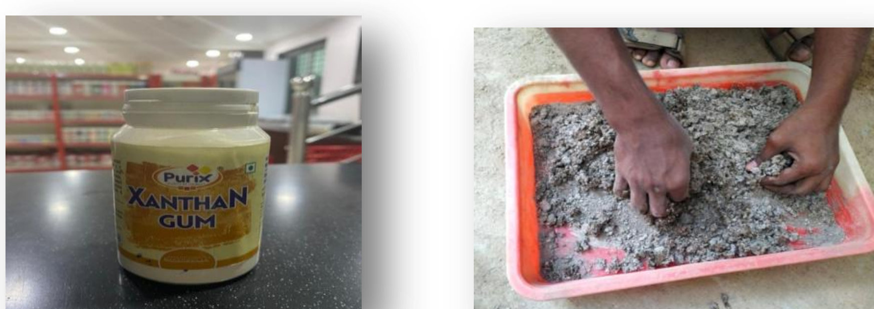


Fig 4 : xantham gum bottle and mixing with soil sample.

Reaction with soil:
The results show that the Xanthan gum fibers interact directly with the charged surfaces of clayey particles while forming Xanthan matrices that resemble a tough plastic between uncharged particles.
Consequently, the strengthening effect of Xanthan gum was shown to possess the best efficiency with well graded soils with fine particles.

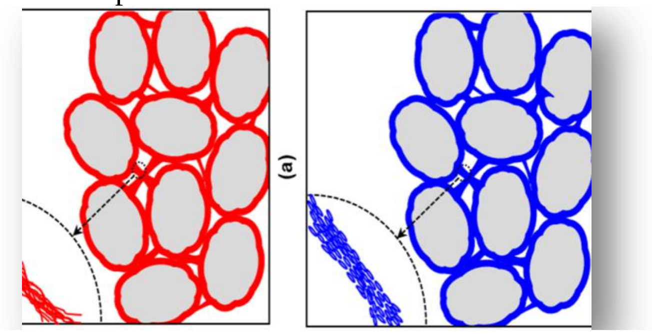


Fig5 : xanthan Gum reaction with clay Particles

2.3 METHODOLOGY / EXPERIMENTAL PROCEDURE

In this methodology which is embraced of xanthan gum with black cotton soil and procedure of directing analysis are displayed. Prior to that, experimental procedures for basic properties of black cotton soil such as sieve analysis, specific gravity and Atterberg limits are classified. Further, methodology which is adopted for finding out engineering properties like max dry density (MDD), optimum moisture content (OMC) and CBR resistance values of both black cotton soil and xanthan gum are exhibited. Laboratory experiments such as standard proctor compaction test, and CBR tests are performed for black cotton soil mixed with different percentages (0.02%, 0.03%, 0.04%, 0.05% & 0.06%) of xanthan gum by weight.
Table 3.1 experiments performed in the study

S.no	Black Cotton Soil
1	Specific gravity of soil solids (IS: 2720- PART 3-1980)
2	Particle size analysis (IS : 2720-PART 5-1985)
3	Atterberg Limits (IS : 2720-5-1985)
4	Compaction Test (IS : 2720-PART 7-1980)
5	Unconfined Compressive Strength (IS : 2720-PART 10-1991)
6	California Bearing Ratio Test (IS:2720-PART 16-1987)

2.4 Sample Mixing : For the sample preparation, two different mixing methods can be adopted: dry mixing in which the biopolymer was directly mixed with the soil before adding water and wet mixing in which biopolymer was mixed with water to form hydro- solution before mixing in the soil. Dry mixing method was used. Soil sample mixed with various percentage of biopolymer (0.02%, 0.03%, 0.04%, 0.05%,& 0.06%).

3.0 RESULTS AND DISCUSSIONS

Methodologies which are adopted for compaction test, unconfined compressive test and consolidation and bearing ratio (CBR) tests have been discussed in chapter 3. Test procedures for specific gravity of soil solids, dry sieve analysis, liquid limit and plastic limit are discussed in chapter 3. In this section, detail test results for both black cotton soil and BCS mixed with xanthan gum are presented. First, results for specific gravity and basic properties or index properties (sieve analysis, LL and, PL) of black cotton soil are presented. Based on the index properties results, soil classification of black cotton soil has been done as per IS soil arrangement. Detailed results and discussions for each mentioned tests are presented. Results for black cotton soil mixed with different percentages (0.02%, 0.03%, 0.04%, 0.05%,& 0.06%) of xanthan gum are presented. Based on the each test results corresponding discussions and recommendations are presented. Further, for each all tests with different percentages of xanthan gum corresponding tables and graphs are presented. Based on the nature of graphs, discussions are made. Percentages of increase in properties of xanthan gum with black cotton soil are presented and the comparisons between are shown.

3.1 Results / properties of Black Cotton Soil: In this section, the test results and corresponding discussions for black cotton soil are presented. The following table present the results for specific gravity, sieve analysis, free swell index (FSI),liquid limit (LL), plastic limit (PL), compaction test, and California bearing ratiotest(CBR).

Table 2 : properties of expansive soils

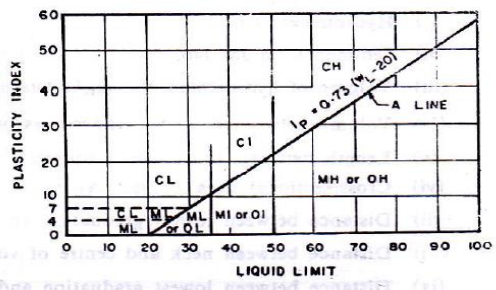
Sample 1	**Sample 2**
Place : farming field near high wayside **properties:** sieve analysis -- >50% retained (60%) Specific gravity – 2.65 Liquid limit (LL)– 33% Plastic limit (PL)– 24.47% plasticity index (PI) – 8.53% **Soil type** :clayey sand (inorganic course grain)	**Place :**agriculture field near highway road **properties:** sieve analysis -- >50% passed (84%) Specific gravity – 2.4 Liquid limit (LL) – 62.5% Plastic limit (PL) – 28% Plasticity index (PI)– 34.5% Free Swell index (FSI)– 95% **Soil type :** clay of high compressibility (CH) **(**inorganic clayey)

Plasticity index on A-line =0.73(LL-20)

= 0.73 (62.5-20)

=31.025 %

Since plasticity index of soil is greater then plasticity index on A-line . So the natural soil is classified as clay with highly compressible (CH).

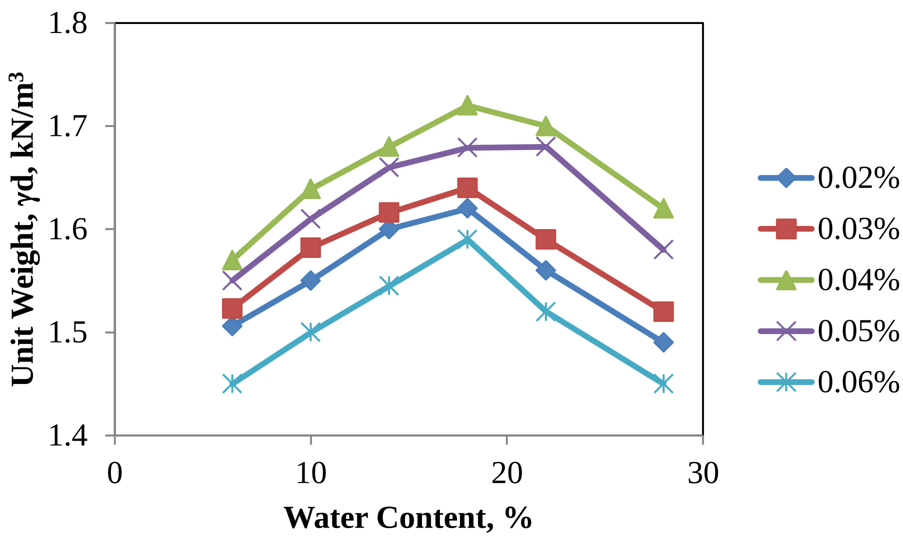


Plasticity index	Soil type	Degree of plasticity	Degree of cohesiveness
0	Sand	Non-plastic	Non cohesive
<7	Silt	Low-plastic	Partly cohesive
7–17	Silt clay	Med. plastic	Cohesive
> 17	Clay	High plastic	Cohesive

Fig3: plasticity index chart and corresponding range

3.2. Compaction Test:

Test procedure for conducting standard proctor test has been discussed in the previous chapter. In this section, standard proctor test results are presented for black cotton soil and corresponding discussions have been made. Table 4.5 shows the standard proctor test results of natural soil in which dry densities and water contents are presented. From the above graph it is noted that the maximum dry density () and optimum moisture content () of black cotton soil are 1.658g/cc and 19.404% respectively. From the graph it is also observed that MDD is increased constantly and reaches maximum at 19.404% OMC and after reaching the maximum point the MDD decreased. Range of MDD for black cotton soil is between 1.6-1.7 g/cc.

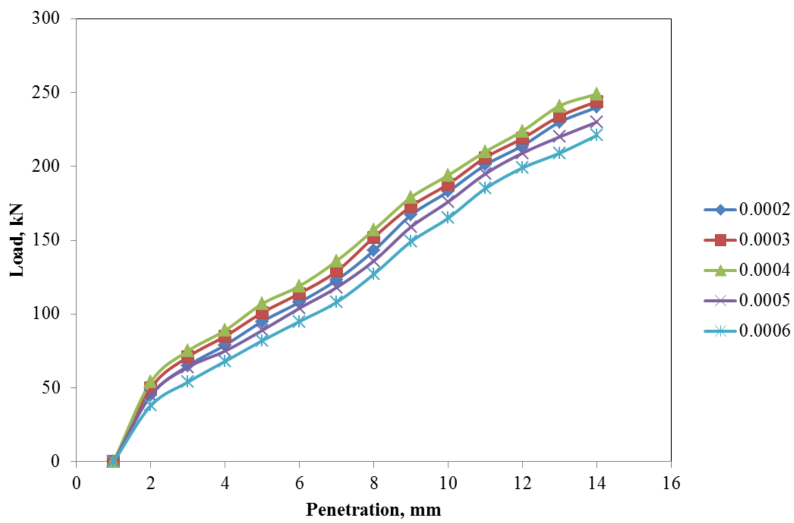


3.3 California bearing ratio (CBR) test for black cotton soil:

The test procedure for California bearing ratio (CBR) test procedure for xanthan gum mixed with black cotton soil is discussed in the methodology part of chapter 3. In this section CBR test results of xanthan gum mixed in black cotton soil are presented. Series of CBR tests rae performed and results are presented for BCS with varying percentages (0.02%, 0.03%, 0.04%, 0.05% & 0.06%) of xanthan gum. The CBR test is conducted for black cotton soil and the results are discussed in the previous section. The CBR values of black cotton soil ontained from CBR test at 2.5mm and 5mm depth of penetration are 6.78% and 6.18% respectively. The higher value of those CBR values is generally adopted for design purpose, so the CBR value for black cotton soil is found to be 6.78%. this CBR value used to evaluate the percentage of increment and decrement in CBR values for CBR test results of xanthan gum mixed in BCS and evaluated percentage increment and / or decrement in CBR values are presented .

3.4 Effect of 0.02% xanthan gum on BCS: From the above table it is concluded that there is a gradual increment in the values of California bearing ratio (CBR) with the increase in percentage of xanthan gum mixed with black cotton soil. From the above table it is concluded that there is a gradual increment in the values of California bearing ratio (CBR) with the increase in percentage of xanthan gum mixed with black cotton soil.

% of Xanthan gum	CBR values	
	2.5mm	5mm
0.02%	7.69%	9.88%
0.03%	8.15%	9.95%
0.04%	8.60%	10.26%
0.05%	7.92%	9.50%
0.06%	7.24%	7.39%



4.0 CONCLUSION

As a result of soil stabilization, the bearing capacity of the foundation of the structures is increased and its strength, water tightness, resistance to washout, and other properties are improved. Soil stabilization is widely used in the construction on sagging soils of industrial and civil buildings. Xanthan gum stabilization has shown little to very high improvement in physical properties of soils. This little improvement may be due to chemical consistent of the soil. Therefore, it is advisable to first examine for first it show the changes in soil morphological characteristics due to the interaction between the biopolymers strings and fine-grained particles of the soil.

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